Appendix Y:
Emission Inventories for Alternatives

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Y. Emission Inventories for Alternatives

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Alternative A Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.6	241.1	0.5	28.8	4.1	15.2	6,290.4	38.6	0.0	7,112.9
Natural Gas	10.8	4.6	3.1	0.1	4.9	0.7	0.3	1,044.4	13.9	0.0	1,333.4
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining [1]	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management [2]	433.2	19.4	23.2	3.9	55.7	38.0	13.3	309,072.5	154.6	31.3	322,494.4
Forestry Management	0.6	0.8	0.1	0.0	2.9	0.3	0.0	94.1	0.0	0.0	94.5
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	2.9	0.0	0.7	0.0	13.7	1.4	0.1	10.2	0.0	0.0	10.5
Federal Emission Total	**536.7**	**80.7**	**271.1**	**4.6**	**507.9**	**85.0**	**29.1**	**317,111.8**	**479.9**	**31.4**	**337,392.1**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	119.7	21.0	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.5	28.8	13.1	0.4	20.0	3.3	1.3	4,176.2	55.6	0.0	5,328.7
Non-Federal Emission Total	**293.4**	**236.3**	**981.9**	**2.3**	**139.7**	**24.3**	**62.7**	**29,337.7**	**209.8**	**0.1**	**33,760.2**

tpy = short tons per year

[1] To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. $PM_{2.5}$ emissions are assumed to be 10 percent of PM_{10} emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

[2] Excludes emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	54,931	16,068	8,949	8,147	32,692	4,533
Alt. A (%) of NEI Emissions	1.0%	0.5%	3.0%	0.1%	1.6%	1.9%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. A (%) without Mine Emissions	1.0%	0.4%	3.0%	0.1%	1.5%	1.8%

Alternative B Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.6	241.1	0.5	28.8	4.1	15.2	6,290.4	38.6	0.0	7,112.9
Natural Gas	10.8	4.6	3.1	0.1	4.9	0.7	0.3	1,044.4	13.9	0.0	1,333.4
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining 1	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management 2	1,475.6	48.5	76.5	11.9	172.7	129.0	18.7	309,076.8	209.8	39.3	326,137.0
Forestry Management	0.9	1.2	0.1	0.0	6.3	0.7	0.0	148.9	0.0	0.0	149.7
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	0.5	0.0	0.1	0.0	2.3	0.2	0.0	1.7	0.0	0.0	1.8
Federal Emission Total	**1,577.0**	**110.2**	**323.8**	**12.5**	**617.0**	**175.1**	**34.4**	**317,162.5**	**535.1**	**39.4**	**341,081.1**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	119.7	21.0	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.5	28.8	13.1	0.4	20.0	3.3	1.3	4,176.2	55.6	0.0	5,328.7
Non-Federal Emission Total	**293.4**	**236.3**	**981.9**	**2.3**	**139.7**	**24.3**	**62.7**	**29,337.7**	**209.8**	**0.1**	**33,760.2**

tpy = short tons per year

1 To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. PM2.5 emissions are assumed to be 10 percent of PM10 emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

2 Excludes emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	54931	16068	8949	8147	32692	4533

Alt. B (%) of NEI Emissions	2.9%	0.7%	3.6%	0.2%	1.9%	3.9%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. B (%) without Mine Emissions	2.9%	0.5%	3.6%	0.2%	1.8%	3.8%

Alternative C Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.6	241.1	0.5	28.8	4.1	15.2	6,290.4	38.6	0.0	7,112.9
Natural Gas	10.8	4.6	3.1	0.1	4.9	0.7	0.3	1,044.4	13.9	0.0	1,333.4
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining 1	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management 2	1,477.8	48.5	76.9	11.9	164.0	128.0	18.7	309,080.4	209.8	39.3	326,140.6
Forestry Management	1.4	1.9	0.2	0.0	15.4	1.7	0.0	243.0	0.0	0.0	244.2
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	2.2	0.0	0.5	0.0	10.4	1.1	0.1	7.8	0.0	0.0	8.0
Federal Emission Total	**1,581.5**	**111.0**	**324.7**	**12.6**	**625.5**	**175.9**	**34.5**	**317,266.2**	**535.1**	**39.4**	**341,185.4**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	119.7	21.0	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.5	28.8	13.1	0.4	20.0	3.3	1.3	4,176.2	55.6	0.0	5,328.7
Non-Federal Emission Total	**293.4**	**236.3**	**981.9**	**2.3**	**139.7**	**24.3**	**62.7**	**29,337.7**	**209.8**	**0.1**	**33,760.2**

tpy = short tons per year

1 To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. PM2.5 emissions are assumed to be 10 percent of PM10 emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

2 Excludes emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	54931	16068	8949	8147	32692	4533
Alt. C (%) of NEI Emissions	2.9%	0.7%	3.6%	0.2%	1.9%	3.9%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. C (%) without Mine Emissions	2.9%	0.5%	3.6%	0.2%	1.8%	3.8%

Alternative D Summary

BiFO Future Year Emission Estimate Summary

Ownership	Emissions (tpy)										
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$	HAPs	CO_2	CH_4	N_2O	CO_{2eq}
Federal / BLM											
Oil and Gas Development and Production											
Oil	67.4	30.6	241.1	0.5	28.8	4.1	15.2	6,290.4	38.6	0.0	7,112.9
Natural Gas	10.8	4.6	3.1	0.1	4.9	0.7	0.3	1,044.4	13.9	0.0	1,333.4
BLM Travel	1.3	0.5	0.6	0.0	54.9	5.5	0.1	85.6	0.0	0.0	89.0
BLM Road Maintenance	0.2	0.5	0.0	0.0	1.7	0.2	0.0	60.4	0.0	0.0	60.6
Coal Mining 1	11.3	23.7	1.2	0.0	29.9	3.0	---	274.4	0.0	0.0	274.4
Fire Management 2	1,475.7	48.4	76.5	11.9	171.2	128.9	18.7	309,060.3	209.8	39.3	326,120.3
Forestry Management	1.2	1.5	0.2	0.0	10.3	1.1	0.0	196.0	0.0	0.0	197.0
Livestock Grazing	0.4	0.4	0.1	0.0	88.7	8.9	0.0	73.5	272.8	0.0	5,803.8
Recreation and Visitor Services	8.6	0.2	0.9	0.0	226.9	22.8	0.1	106.4	0.0	0.0	118.5
Vegetation Management	1.2	0.0	0.3	0.0	5.6	0.6	0.0	4.2	0.0	0.0	4.3
Federal Emission Total	**1,578.1**	**110.5**	**324.0**	**12.5**	**622.8**	**175.8**	**34.4**	**317,195.5**	**535.1**	**39.4**	**341,114.1**
Non-Federal											
Oil and Gas Development and Production											
Oil	250.9	207.5	968.8	1.9	119.7	21.0	61.4	25,161.5	154.2	0.1	28,431.4
Natural Gas	42.5	28.8	13.1	0.4	20.0	3.3	1.3	4,176.2	55.6	0.0	5,328.7
Non-Federal Emission Total	**293.4**	**236.3**	**981.9**	**2.3**	**139.7**	**24.3**	**62.7**	**29,337.7**	**209.8**	**0.1**	**33,760.2**

tpy = short tons per year

1 To be conservative, coal mining emissions are assumed to result from coal mined from BLM mineral estate. Coal mine emissions reflect ongoing operations at the Signal Peak Energy, LLC coal mine located in Musselshell County. Only PM10 emissions are included in the mine's state-issued permit. PM2.5 emissions are assumed to be 10 percent of PM10 emissions. Criteria air pollutants and greenhouse gases are estimated by scaling emissions from coal mines in the MCFO based on production.

2 Excludes emissions from wildfires.

Comparison to Current Total County Emissions

Emissions	Emissions (tpy)					
	CO	NO_x	VOC	SO_2	PM_{10}	$PM_{2.5}$
2008 NEI Emissions	54931	16068	8949	8147	32692	4533
Alt. D (%) of NEI Emissions	2.9%	0.7%	3.6%	0.2%	1.9%	3.9%

County Emissions (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, Yellowstone)

Source: USEPA 2011e.

Alt. D (%) without Mine Emissions	2.9%	0.5%	3.6%	0.2%	1.8%	3.8%

Oil Wells - Alternatives A, B, C, and D

Alternatives A, B, C, and D input parameters for calculating oil wells emissions:

Maximum Annual Wells Drilled - Federal (RMP estimate)	3	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	12
Federal Producing Wells - RMP Year 20	60	Non-Federal Producing Wells - RMP Year 20	240
Average Well Barrel Oil Per Day (BOPD)	20	Average Well Barrel Oil Per Day (BOPD)	20

* 100% full RMP estimates for Federal, full RMP estimates (100%) for non-Federal

Federal Oil Wells Summaries

Total Annual Emissions from Federal Oil Wells - RMP Year - Alternatives A, B, C, and D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.15	0.01	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.08	0.08	1.63	0.32	8.27	0.45	0.04	1650.30	0.02	0.02	1656.49	1503.17
Commuting Vehicles - Construction	15.90	1.60	0.15	0.00	0.18	0.06	0.01	40.04	0.00	0.00	40.93	37.14
Wind Erosion	0.04	0.01	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**16.17**	**1.70**	**1.78**	**0.32**	**8.45**	**0.51**	**0.05**	**1,690.34**	**0.02**	**0.02**	**1,697.42**	**1,540.31**
Well Workover Operations - Fugitive Dust	0.85	0.09	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.02	0.02	0.36	0.14	3.10	0.17	0.02	630.45	0.01	0.01	632.87	574.29
Well Workover Operations - On-road Exhaust	0.00	0.00	0.03	0.00	0.06	0.02	0.002	7.44	0.00	0.00	7.65	6.94
Well Visits for Inspection & Repair - Operations	2.09	0.21	0.01	0.00	0.21	0.01	0.001	4.10	0.00	0.00	4.59	4.16
Recompletion Traffic	1.47	0.15	0.06	0.00	0.10	0.04	0.00	15.10	0.00	0.00	15.49	14.05
Water Tanks & Traffic	4.72	0.50	0.40	0.00	0.26	0.05	0.01	117.63	6.86	0.00	262.01	237.76
Oil Tanks & Traffic	0.98	0.12	0.26	0.00	0.17	212.18	12.23	87.42	24.18	0.00	595.45	540.34
Venting	---	---	---	---	---	2.34	0.19	0.08	2.93	0.00	61.53	55.83
Compression and Well Pumps	1.22	1.22	27.52	0.02	55.04	19.26	1.93	3,713.41	0.07	0.01	3717.06	3373.01
Dehydrators	0.00	0.00	0.00	0.00	0.00	6.31	0.78	4.08	4.22	0.00	92.80	84.21
Compression Station Fugitives	---	---	---	---	---	0.21	0.02	0.01	0.26	0.00	5.55	5.04
Sub-total: Operations	**11.35**	**2.30**	**28.65**	**0.16**	**58.92**	**240.59**	**15.18**	**4,579.70**	**38.54**	**0.02**	**5,394.99**	**4,895.64**
Road Maintenance	1.02	0.11	0.13	0.003	0.06	0.02	0.002	16.39	0.00	0.00	16.49	14.96
Sub-total: Maintenance	**1.02**	**0.11**	**0.13**	**0.003**	**0.06**	**0.02**	**0.002**	**16.391**	**0.000**	**0.00**	**16.49**	**14.96**
Road Reclamation	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.13	0.12
Well Reclamation	0.21	0.02	0.02	0.00	0.02	0.00	0.00	3.82	0.00	0.00	3.84	3.48
Sub-total: Reclamation	**0.21**	**0.02**	**0.02**	**0.0007**	**0.02**	**0.003**	**0.0003**	**3.9514**	**0.0001**	**0.0001**	**3.9715**	**3.6039**
Total Emissions	**28.75**	**4.14**	**30.58**	**0.49**	**67.45**	**241.12**	**15.23**	**6,290.38**	**38.56**	**0.04**	**7,112.88**	**6,454.52**

Oil Wells - Alternatives A, B, C, and D

Non-Federal Oil Wells Summaries

Total Annual Emissions from Non-Federal Oil Wells - RMP Year - Alternatives A, B, C, and D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.59	0.06	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	3.22	3.14	61.28	1.27	15.85	4.48	0.45	6601.19	0.07	0.02	6608.46	5996.79
Commuting Vehicles - Construction	63.59	6.40	0.61	0.00	0.73	0.25	0.03	160.16	0.01	0.00	161.15	146.24
Wind Erosion	0.18	0.03	---	---	---	---	---	---	---	---	---	---
Sub-total: Construction	**67.58**	**9.62**	**61.90**	**1.28**	**16.58**	**4.74**	**0.47**	**6,761.35**	**0.07**	**0.02**	**6,769.61**	**6,143.03**
Well Workover Operations - Fugitive Dust	3.41	0.34	---	---	---	---	---			---	---	---
Well Workover Operations - On-site Exhaust	1.81	1.76	31.87	0.54	10.71	2.31	0.23	2521.79	0.04	0.03	2531.46	2297.15
Well Workover Operations - On-road Exhaust	0.01	0.01	0.13	0.00	0.23	0.09	0.009	29.76	0.00	0.00	30.59	27.76
Well Visits for Inspection & Repair - Operations	8.35	0.83	0.04	0.00	0.82	0.04	0.004	16.40	0.00	0.01	18.35	16.65
Recompletion Traffic	5.87	0.60	0.25	0.00	0.40	0.16	0.02	60.38	0.00	0.00	61.94	56.21
Water Tanks & Traffic	18.89	2.01	1.61	0.01	1.02	0.21	0.02	470.50	27.45	0.00	1048.06	951.05
Oil Tanks & Traffic	3.93	0.47	1.05	0.01	0.66	848.73	48.92	349.66	96.73	0.00	2381.81	2161.35
Venting	---	---	---	---	---	9.35	0.76	0.30	11.71	0.00	246.12	223.34
Compression and Well Pumps	4.88	4.88	110.08	0.07	220.16	77.06	7.71	14,853.66	0.28	0.03	14868.23	13492.04
Dehydrators	0.00	0.00	0.01	0.00	0.01	25.23	3.13	16.30	16.90	0.00	371.19	336.84
Compression Station Fugitives	---	---	---	---	---	0.84	0.08	0.03	1.06	0.00	22.21	20.16
Sub-total: Operations	**47.15**	**10.90**	**145.05**	**0.63**	**234.02**	**964.01**	**60.87**	**18,318.79**	**154.16**	**0.08**	**21,579.96**	**19,582.54**
Road Maintenance	4.08	0.43	0.52	0.014	0.24	0.07	0.007	65.56	0.00	0.00	65.97	59.86
Sub-total: Maintenance	**4.08**	**0.43**	**0.52**	**0.014**	**0.24**	**0.07**	**0.007**	**65.564**	**0.001**	**0.00**	**65.97**	**59.86**
Road Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.53	0.48
Well Reclamation	0.83	0.09	0.06	0.00	0.07	0.01	0.00	15.28	0.00	0.00	15.36	13.94
Sub-total: Reclamation	**0.85**	**0.10**	**0.06**	**0.0028**	**0.07**	**0.014**	**0.0014**	**15.8057**	**0.0003**	**0.0002**	**15.8859**	**14.4155**
Total Emissions	**119.66**	**21.04**	**207.53**	**1.93**	**250.91**	**968.83**	**61.36**	**25,161.51**	**154.24**	**0.10**	**28,431.42**	**25,799.84**

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Emissions Estimation for Construction Activities

Area Disturbed for Oil Wells	Avg. Disturbed Acres per well	Construction Days	Total # of Wells	Total Disturbed Acres	Emissions (lbs/well)		Emissions (tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	1.5	3	1	1.5	3.30E+01	3.30E+00	1.65E-02	1.65E-03
Well Pad and other structures	3.0	3	1	3.0	6.60E+01	6.60E+00	3.30E-02	3.30E-03
			Total		**9.90E+01**	**9.90E+00**	**4.95E-02**	**4.95E-03**

Number of acres per well pad provided by data in Billings Field Office Resource Management Plan.

Oil Wells - Alternatives A, B, C, and D

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)									Equipment Category
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	4.37	0.34	0.12	1.52	0.35	0.33	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	4.85	0.57	0.13	3.94	0.50	0.55	594.65	0.008	0.006	Motor Grader

Source: EPA NONROADS 2008a

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

NOTE: Use emission factors for 2008 for all project years = conservative estimate of fleet turnover

Emission Estimations for Construction Equipment (using 2008 emission factors)

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions													
									(lbs/equipment type/well)					(tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.47	0.000	0.000
Well Pad	Blade	175	1	75	10	3	30	1	42.10	4.95	1.13	34.20	4.34	0.02	0.00	0.00	0.02	0.00	0.00	2.58	0.000	0.000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.75	0.000	0.000
													Subtotal	5.33E-02	5.46E-03	1.44E-03	3.39E-02	5.03E-03	6.30E-03	6.81E+00	8.64E-05	6.93E-05

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.12	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.11	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.11	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.11	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.11	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.11	2.60	0.14	0.02	530.28	0.004	0.006
>750	0.50	0.022	0.10	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. EPA NONROADS 2008a (Year 2008) for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions													
									(lbs/equipment type/well)					(tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	889	39	182	4,622	249	0.44	0.02	0.09	2.31	0.12	0.02	471.0	0.005	0.005
	Auxiliary Pump	600	1	80	8	15	120	1	38	2	15	330	18	0.02	0.00	0.01	0.17	0.01	0.00	33.7	0.000	0.000
	Generators	150	2	75	24	8	192	1	29	1	11	352	13	0.01	0.00	0.01	0.18	0.01	0.00	25.2	0.000	0.000
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	11	1	4	95	5	0.01	0.00	0.00	0.05	0.00	0.00	9.6	0.000	0.000
	Auxiliary Pump	225	1	80	8	2	16	1	2	0	1	17	1	0.00	0.00	0.00	0.01	0.00	0.00	1.7	0.000	0.000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.1	0.000	0.000
	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)[b]	# of Operating Hours/ Day	# of Operating Days/ Well	# of Operating Hours/ Well	# of Wells														
	Field Generators for Pumps & Lighting	55	1	75	12	3	36	1	11.46	0.07	0.38	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	1.0	0.000	0.000
													Subtotal	4.91E-01	2.16E-02	1.06E-01	2.72E+00	1.43E-01	2.16E-02	5.43E+02	5.60E-03	6.20E-03
													Total	5.44E-01	2.71E-02	1.08E-01	2.76E+00	1.49E-01	2.79E-02	5.50E+02	5.69E-03	6.27E-03

Oil Wells - Alternatives A, B, C, and D

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)									Equipment Category
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	4.37	0.34	0.12	1.52	0.35	0.33	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	4.85	0.57	0.13	3.94	0.50	0.55	594.65	0.008	0.006	Motor Grader

Source: EPA NONROADS 2008a

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

NOTE: Use emission factors for 2008 for all project years = conservative estimate of fleet turnover

Emission Estimations for Construction Equipment (using 2008 emission factors)

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.47	0.000	0.000
Well Pad	Blade	175	1	75	10	3	30	1	42.10	4.95	1.13	34.20	4.34	0.02	0.00	0.00	0.02	0.00	0.00	2.58	0.000	0.000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.75	0.000	0.000
													Subtotal	5.33E-02	5.46E-03	1.44E-03	3.39E-02	5.03E-03	6.30E-03	6.81E+00	8.64E-05	6.93E-05

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.10	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.10	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.10	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.18	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.25	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.28	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.92	0.006	0.006

Source: EPA NONROADS 2008a - Year 2018 accounts for mixture of Tier 1-3 engines

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	1,000	3	70	24	16	384	1	9,126	462	182	2,291	661	4.56	0.23	0.09	1.15	0.33	0.22	471.0	0.005	0.005
	Auxiliary Pump	600	1	80	8	15	120	1	459	27	13	134	33	0.23	0.01	0.01	0.07	0.02	0.01	33.7	0.000	0.000
	Generators	150	2	75	24	8	192	1	340	25	10	95	30	0.17	0.01	0.00	0.05	0.01	0.01	25.2	0.000	0.000
Well Completion & Testing	Main Deck	600	1	50	11	5	55	1	131	8	4	38	9	0.07	0.00	0.00	0.02	0.00	0.00	9.6	0.000	0.000
	Auxiliary Pump	225	1	80	8	2	16	1	21	1	1	5	2	0.01	0.00	0.00	0.00	0.00	0.00	1.7	0.000	0.000
	Power Swivel	150	1	75	8	2	16	1	14	1	0	4	1	0.01	0.00	0.00	0.00	0.00	0.00	1.1	0.000	0.000
	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)[b]	# of Operating Hours/ Day	# of Operating Days/ Well	# of Operating Hours/ Well	# of Wells														
	Field Generators for Pumps & Lighting	55	1	75	12	3	36	1	14.90	1.33	0.38	6.98	1.38	0.01	0.00	0.00	0.00	0.00	0.00	1.0	0.000	0.000
													Subtotal	5.05E+00	2.63E-01	1.05E-01	1.29E+00	3.69E-01	2.55E-01	5.43E+02	5.60E-03	6.20E-03
													Total	5.11E+00	2.69E-01	1.06E-01	1.32E+00	3.74E-01	2.62E-01	5.50E+02	5.69E-03	6.27E-03

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k\,(s/12)^a\,(W/3)^b$	k	1.5	0.15
		a	0.9	0.9
		b	0.45	0.45
E_{ext} = E (1 - P/365)				

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Road Traffic - All Project Years

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ (tons/well)
Improved & Two-Track Road	Semi Trucks	42	6	47	282	1	1.50	423.74	0.21	0.22	0.15	42.37	0.02	0.02
	Pickup Trucks	5	6	3	18	1	0.58	10.38	0.01		0.06	1.04	0.00	
Well Pad	Semi Trucks	42	6	5	30	1	1.50	45.08	0.02	0.03	0.15	4.51	0.00	0.00
	Pickup Trucks	5	6	4	24	1	0.58	13.84	0.01		0.06	1.38	0.00	
Other Construction Activities	Semi Trucks	42	6	2	12	1	1.50	18.03	0.01	0.02	0.15	1.80	0.00	0.00
	Haul Trucks	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
	Pickup Trucks	5	6	1	6	1	0.58	3.46	0.00		0.06	0.35	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	6	44	264	1	1.50	396.69	0.20	0.47	0.15	39.67	0.02	0.05
	Fuel Haul Truck	25	6	6	36	1	1.19	42.83	0.02		0.12	4.28	0.00	
	Mud Haul Truck, Water Hauling	25	6	4	24	1	1.19	28.55	0.01		0.12	2.86	0.00	
	Rig Crew	5	6	51	306	1	0.58	176.46	0.09		0.06	17.65	0.01	
	Rig Mechanics	5	6	2	12	1	0.58	6.92	0.00		0.06	0.69	0.00	
	Co. Supervisor	5	6	20	120	1	0.58	69.20	0.03		0.06	6.92	0.00	
	Tool Pusher	25	6	8	48	1	1.19	57.11	0.03		0.12	5.71	0.00	
	Mud Logger	25	6	6	36	1	1.19	42.83	0.02		0.12	4.28	0.00	
	Mud Engineer	25	6	15	90	1	1.19	107.08	0.05		0.12	10.71	0.01	
	Logger, Engr Truck	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Drill Bit Delivery	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
Well Completion & Testing (continued below)	Semi Casing Haulers	42	6	6	36	1	1.50	54.09	0.03	0.07	0.15	5.41	0.00	0.01
	Semi Completion, Unit Rig	42	6	1	6	1	1.50	9.02	0.00		0.15	0.90	0.00	
	Semi Fracing, Blender	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Semi Pumping/Tank Battery	25	6	6	36	1	1.19	42.83	0.02		0.12	4.28	0.00	
	Tubing Truck	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
	Haul Cementer, Pump Truck	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
									Subtotal	**8.10E-01**				**8.10E-02**

Oil Wells - Alternatives A, B, C, and D

Emission Estimations for Road Traffic - All Project Years (continued)

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle type)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle type)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ (tons/well)
	Haul Cementer, Cement Truck	25	40	3	120	1	1.19	142.77	0.07		0.12	14.28	0.01	
	Haul Completion,	25	40	3	120	1	1.19	142.77	0.07		0.12	14.28	0.01	
	Haul Service Tools	25	40	2	80	1	1.19	95.18	0.05		0.12	9.52	0.00	
	Haul Perforators Logging Truck	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Anchor, Installation	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Anchor, Testing	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Fracing, Tank	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Fracing, Pump	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Fracing, Chemical	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Fracing, Sand	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Fracing, Other	25	40	1	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Haul Welders	25	40	6	240	1	1.19	285.54	0.14		0.12	28.55	0.01	
Well Completion & Testing (continued from above)	Haul Water Truck	25	40	150	6000	1	1.19	7,138.57	3.57	4.48	0.12	713.86	0.36	0.45
	Pickup Cementer, Engineer	5	40	2	80	1	0.58	46.13	0.02		0.06	4.61	0.00	
	Pickup Casing Crew	5	40	2	80	1	0.58	46.13	0.02		0.06	4.61	0.00	
	Pickup Completion Crew	5	40	5	200	1	0.58	115.33	0.06		0.06	11.53	0.01	
	Pickup Completion, Pusher	5	40	5	200	1	0.58	115.33	0.06		0.06	11.53	0.01	
	Pickup Perforators, Engineer	5	40	2	80	1	0.58	46.13	0.02		0.06	4.61	0.00	
	Pickup Fracing, Engineer	5	40	1	40	1	0.58	23.07	0.01		0.06	2.31	0.00	
	Pickup Co. Supervisor	5	40	10	400	1	0.58	230.67	0.12		0.06	23.07	0.01	
	Pickup Miscellaneous Supplies	5	40	3	120	1	0.58	69.20	0.03		0.06	6.92	0.00	
	Pickup Roustabout Crew	5	40	4	160	1	0.58	92.27	0.05		0.06	9.23	0.00	
									Subtotal	4.48E+00				4.48E-01
								Total		5.29E+00				5.29E-01

Oil Wells - Alternatives A, B, C, and D

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions																					
							(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)									
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	HDDV	40	47	1880	1	11.2568	1.1406	0.9520	0.0547	7.1329	1.4672	0.0056	0.0006	0.0005	0.0000	0.0036	0.0007	0.006	0.001	0.000	0.000	0.004	0.001	1.6	0.0001	0.0001
	Pickup Trucks	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.0000	0.0000
Well Pad	Semi Trucks	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001	0.001	0.000	0.000	0.000	0.001	0.001	0.2	0.0000	0.0000
	Pickup Trucks	LDDT	40	4	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005							0.1	0.0000	0.0000
Other Construction Activities	Semi Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000	0.001	0.000	0.000	0.000	0.001	0.000	0.1	0.0000	0.0000
	Haul Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Pickup Trucks	LDDT	40	1	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001							0.0	0.0000	0.0000
																		Subtotal	**7.52E-03**	**7.18E-04**	**5.98E-04**	**3.46E-05**	**6.45E-03**	**1.84E-03**	**2.10E+00**	**9.21E-05**	**1.28E-04**

Oil Wells - Alternatives A, B, C, and D

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/Year	Miles Traveled/Well/Year	Total # of Wells	Emissions																				
	Type	Class					(lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
							NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	40	44	1760	1	10.5383	1.0678	0.8913	0.0512	6.6776	1.3735	0.0053	0.0005	0.0004	0.0000	0.0033	0.0007	0.02	0.00	0.00	0.00	0.03	0.01	1.5	0.0001	0.0001
	Fuel Haul Truck	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
	Rig Crew	LDDT	40	51	2040	1	10.3979	0.4889	0.3980	0.0252	28.0950	12.3542	0.0052	0.0002	0.0002	0.0000	0.0140	0.0062							0.9	0.0000	0.0001
	Rig Mechanics	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Co. Supervisor	LDDT	40	20	800	1	4.0776	0.1917	0.1561	0.0099	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.0000	0.0000
	Tool Pusher	LDDT	40	8	320	1	1.6310	0.0767	0.0624	0.0040	4.4071	1.9379	0.0008	0.0000	0.0000	0.0000	0.0022	0.0010							0.1	0.0000	0.0000
	Mud Logger	LDDT	40	6	240	1	1.2233	0.0575	0.0468	0.0030	3.3053	1.4534	0.0006	0.0000	0.0000	0.0000	0.0017	0.0007							0.1	0.0000	0.0000
	Mud Engineer	LDDT	40	15	600	1	3.0582	0.1438	0.1171	0.0074	8.2632	3.6336	0.0015	0.0001	0.0001	0.0000	0.0041	0.0018							0.3	0.0000	0.0000
	Logger, Engr Truck	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Drill Bit Delivery	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
Well Completion & Testing	Semi Casing Haulers	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001	0.03	0.00	0.00	0.00	0.02	0.01	0.2	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Tubing Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Service Tools	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Installation	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Anchor, Testing	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Tank	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Welders	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Haul Water Truck	HDDV	40	150	6000	1	35.9259	3.6402	3.0384	0.1746	22.7646	4.6825	0.0180	0.0018	0.0015	0.0001	0.0114	0.0023							5.2	0.0002	0.0003
	Pickup Cementer, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Pickup Casing Crew	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Pickup Completion Crew	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001							0.2	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	40	5	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	40	10	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
																		Subtotal	**4.36E-02**	**3.72E-03**	**3.09E-03**	**1.81E-04**	**5.42E-02**	**1.93E-02**	**1.12E+01**	**4.30E-04**	**7.97E-04**
																		Total	**5.11E-02**	**4.44E-03**	**3.69E-03**	**2.15E-04**	**6.07E-02**	**2.11E-02**	**1.33E+01**	**5.22E-04**	**9.25E-04**

Oil Wells - Alternatives A, B, C, and D

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads
Emission Factors for Industrial Unpaved Roads [a]

$E\ (lb/VMT) = k\ (s/12)^a\ (W/3)^b$

$E_{ext} = E\ (1 - P/365)$

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption:	
	Avg. Frequency & Duration: three days, once in the first year; Equipment: Truck-mounted Unit: capacity **600 hp**, fuel **60 gpd**, hours/day **10** Truck: Type **WO rig**, Round trip mileage: **6** miles on unpaved road Max. number of crews in the field on a given day considering weekends and inclement weather: **15**

Fugitive Dust Estimations for Road Traffic

Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/ well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/ well)
Well Workover	WO Rig	42	6	1	6	1	1.50	9.02	0.00	0.15	0.90	0.00
	Haul Truck	42	6	1	6	1	1.50	9.02	0.00	0.15	0.90	0.00
	Pickup Truck	5	6	3	18	1	0.58	10.38	0.01	0.06	1.04	0.00
								Total	**1.42E-02**			**1.42E-03**

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Diesel	0.30	0.02	0.11	2.60	0.14	0.02	529.58	0.007	0.006

Source: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. EPA NONROADS 2008a (Year 2008) for CO2 and CH4.
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Engines

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	5	103	6	**5.95E-03**	**2.98E-04**	**2.26E-03**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Exhaust emission factors for commuting vehicles

Vehicle Type	Class	Emission Factors (g/mi) NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03
Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	(tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.0542	0.0000	0.0000
												Total	**5.45E-04**	**3.86E-05**	**3.20E-05**	**1.90E-06**	**9.78E-04**	**3.95E-04**	**1.24E-01**	**3.53E-06**	**1.09E-05**

Performed once in the first year of well operation
Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Oil Wells - Alternatives A, B, C, and D

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads
Emission Factors for Industrial Unpaved Roads [a]

E (lb/VMT) =	$k (s/12)^a (W/3)^b$
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption: Avg. Frequency & Duration: three days, once in the first year;
Equipment: Truck-mounted Unit: capacity **600 hp**, fuel **60 gpd**, hours/day **10**
Truck: Type **WO rig**, Round trip mileage: **6** miles on unpaved road
Max. number of crews in the field on a given day considering weekends and inclement weather: **15**

Fugitive Dust Estimations for Road Traffic

Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/Year	Miles Traveled/Well/Year	Total # of Wells Drilled	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	6	1	6	1	1.50	9.02	0.00	0.15	0.90	0.00
	Haul Truck	42	6	1	6	1	1.50	9.02	0.00	0.15	0.90	0.00
	Pickup Truck	5	6	3	18	1	0.58	10.38	0.01	0.06	1.04	0.00
								Total	1.42E-02			1.42E-03

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Exhaust Emissions from Well Work Overs
Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
	Emission Factors (gm/hp-hr)								
Diesel	6.69	0.38	0.11	2.25	0.48	0.37	529.58	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Engines

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Exhaust emission factors for commuting vehicles

Vehicle Type	Vehicle Class	NO_x	PM_{10}[a,b]	$PM_{2.5}$[a,b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
		Emission Factors (g/mi)								
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03
Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.0349	0.0000	0.0000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.0542	0.0000	0.0000
												Total	**5.45E-04**	**3.86E-05**	**3.20E-05**	**1.90E-06**	**9.78E-04**	**3.95E-04**	**1.24E-01**	**3.53E-06**	**1.09E-05**

Performed once in the first year of well operation
Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust and Exhaust Emissions from Site Visits and Inspections

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 10, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption:	Frequency of visit: once/week/well Crew: **1** person and **1** light-duty truck Av. number of wells served by a pumper per day **25** Round trip mileage per day: 50 total/20 wells =**2.5** miles/well on unpaved road

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/ well/ yr)	PM_{10} Emissions (tpy/ well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well/yr)	$PM_{2.5}$ Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	2.5	52	130	1	0.53	69.54	**3.48E-02**	0.05	6.95	**3.47E-03**

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03

Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions														
							(lbs/well/yr)						(tpy/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2.5	52	130	1	0.32	0.01	0.00	0.00	6.87	0.31	**1.61E-04**	**3.63E-06**	**1.68E-06**	**1.26E-06**	**3.43E-03**	**1.53E-04**	**6.83E-02**	**9.74E-06**	**2.56E-05**

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust and Exhaust Emissions from Heavy Equipment and Support Vehicles for Road Maintenance
Exhaust Emissions from Heavy Equipment and Support Vehicles for Road Maintenance

Given Data

Maintenance[a]	Equipment/Vehicle			Road Length Worked on/Day (miles)	# of Operating Hours/Day
	Type	Fuel	Capacity (hp)		
Summer	Heavy Equipment[b]	Diesel-30 gpd	135	6	10
	Commuting Vehicle	Gas-5 gpd	225	6	1[c]
Winter	Heavy Equipment[b]	Diesel-30 gpd	135	5	10
	Commuting Vehicle	Gas-5 gpd	225	6	1.5[c]

[a] Road maintenance would be made twice in summer and once in winter every year
[b] Assume a motor grader 135 Hp.
[c] Assume three round trips per two days.

Estimation of Total and Cumulative Length of Roads for the Project - RMP Year 20

Length of Improved Roads per Well (miles)[a]	1.00
Number of Wells	1.00
Cumulative Length of Roads[b] (miles/operation)	1.00

[a] Source: SEIS
[b] miles of road built per well * No. of operating wells/year

Estimation of Total Operation Days and Hours - RMP Year 20

Season	# of Operations per Season	Cumulative Length of Roads (miles/operation)	Road Length Worked On (mi/day)	# of Operating Hours per Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	0.5	5

Emission Factors for Grading - Fugitive Dust

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Em. Factors (lb/VMT)
PM_{10}	$E = (0.6)(0.051)S^2$	5	0.765
$PM_{2.5}$	$E = (0.031)(0.04)S^{2.5}$	5	0.069

[a] S = mean vehicle speed (S), assume 5 mph for grading
Source: EPA AP-42, Section 11.9, Table 11.9-1, Oct 1998

Fugitive Dust Emission Estimations for Grader: RMP Year 20

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
					Emissions (lb/year)	Emissions (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	6.12E-03	1.11	5.55E-04

[a] Assume grader operates at 60% of the time (minus hours for clothing change, breaks, etc)

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	4.34	0.34	0.12	1.51	0.35	0.33	535.77	0.0053	0.006

Source: EPA NONROADS 2008a
Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gal bin, 2545 Btu/hp-hr.

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (lbs/activity/hr)					Emissions (tons/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	2.07E-03	1.62E-04	5.71E-05	7.19E-04	1.67E-04	1.57E-04	2.55E-01	2.52E-06	2.88E-06

[a] Assume grader operates at 60% of the time (minus hours for clothing change, breaks, etc)

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\,(\text{lb/VMT}) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	PM_{10}			$PM_{2.5}$		
						Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)	Emission Factor (lb/VMT)	Emissions (lbs/yr)	Emissions (tpy)
Road Maintenance	Pickup Truck	40	40	1.0	40	0.53	21.40	1.07E-02	0.05	2.14	1.07E-03

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE 6.2.03

[a] Compendium of Greenhouse Gas Emission Methodologies for the Oil and Gas Industry, Table 4-17 for N2O (HDDV moderate control, LDGT oxidation catalyst, LDDT moderate control), Mobile Source Combustion Factors, American Petroleum Institute (2009).

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	Emissions (tpy)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	40	1.0	40	1.02E-04	4.79E-06	3.90E-06	2.47E-07	2.75E-04	1.21E-04	1.81E-02	8.82E-08	2.34E-06

Oil Wells - Alternatives A, B, C, and D

Water Tank and Hauling Emissions

Oil Well Water Tank Flashing Emissions

Project Year	Flashing Loss Emission Factor (lbs CH_4 / 1000 bbl of water) [a]	Water Production (bbl/year/well)	CH4 Emissions (tpy/well)
All	31.31	7300	**1.14E-01**

[a] Average Conditions for Table 5-10 of the API Compedium of GHG Emissions Methodologies for the Oil and Gas Industry, August 2009.

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^{a}\,(S/30)^{d}}{(M/0.5)^{c}} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Road Traffic - Based on Water Produced Per Barrel of Oil

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	Annual # of Round Trips/Well	Miles Traveled/Well	Total # of Wells	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lb/year/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lb/year/well)	$PM_{2.5}$ Emissions (tpy/well)
Produced Water Hauling	Haul Truck (130 bbl)	30	6	56	337	1	0.46	156.07	**7.80E-02**	0.05	15.59	**7.80E-03**

Assume no dust control measures (watering) would be used

Emission Factors for Water Transport Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O [a]
Heavy-Duty Diesel Truck (HDDV)	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.006

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

On-Road Exhaust Emission Estimations for Road Traffic - Based on Water Produced Per Barrel of Oil

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	Annual # of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emissions (lbs/well/yr) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Produced Water Hauling	Haul Truck (130 bbl)	HDDV	40	56	2246	1	13.449	1.363	1.137	0.065	8.522	1.753	**6.72E-03**	**6.81E-04**	**5.69E-04**	**3.27E-05**	**4.26E-03**	**8.76E-04**	**1.96E+00**	**9.16E-05**	**1.50E-05**

Oil Wells - Alternatives A, B, C, and D

Oil Tank, Loadout and Hauling Emissions

Oil Well Oil Seperator Flashing and Tank Emissions [a]

Project Year	Emissions[b] HAPs Emissions (tpy/well)	VOC Emissions (tpy/well)	CO2 Emissions (tpy/well)	CH4 Emissions (tpy/well)
All	**1.77E-01**	**3.18E+00**	**1.82E-01**	**4.03E-01**

[a] Based on average of data from Montana BLM (Laakso, 2010) and calculations using E&P Tanks, July, 2010. Assumes 20 BOPD per well.
[b] Assumes submerged filling with no other emissions control.

Oil Well Oil Truck Loadout VOC Emissions

Emissions were estimated based on EPA, AP-42 Section 5.2.2.1.1 Equation 1

$$L_L = 12.46 \frac{SPM}{T}$$

L_L = Loading Loss pounds per 1000 gallons ($lb/10^3 gal$) of liquid loaded
S = a saturation factor
P = true vapor pressure of liquid loaded, pounds per square inch absolute (psia)
M = molecular weight of vapors, pounds per pounds-mole (lb/lb-mole)
T = temperature of bulk liquid loaded (F+460)

S =	0.6	from EPA, AP-42 Section Table 5.2-1
P =	3.4	from EPA, AP-42 Section Table 7.2-1
M =	50	from EPA, AP-42 Section Table 7.2-1
T =	540	ave. temp.
L_L =	2.35	

Oil Well Oil Truck Loadout Emissions - All Project Years [a]

Project Year	Emission Factor (lbs/1,000 gallons)	Annual Oil Volume (bbl) - per well	Oil (1,000 gallons)	VOC Emissions (tpy/well)	CO_2 Emissions (tpy/well)	CH_4 Emissions (tpy/well)	HAPs Emissions (tpy/well)
All	2.35	7,300	307	**3.61E-01**	**6.47E-04**	**1.05E-07**	**2.68E-02**

[a] Uses E&P Tanks Stream Data for W&S Gas mol % (shown below). E&P Tanks input data from Montana BLM (Laakso, 2010)

Emission Factors for Work Over Vehicles - Road Traffic

Vehicle Class	Emission Factors (g/mi) NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Heavy-Duty Diesel Truck (HDDV)	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.006

Source: MOBILE6.2.03
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

On-Road Exhaust Emission Estimations for Road Traffic - Based on Produced Per Barrel of Oil

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well	Miles Traveled/Well	Total # of Wells	Emissions (lb/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC
Produced Oil Hauling	Haul Truck (200 bbl)	HDDV	40	37	1460	1	8.742	0.886	0.739	0.042	5.539	1.139
						TOTAL						

Activity	Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Produced Oil Hauling	0.0044	0.0004	0.0004	0.0000	0.0028	0.0006	1.274	0.000	0.000
TOTAL	**4.37E-03**	**4.43E-04**	**3.70E-04**	**2.12E-05**	**2.77E-03**	**5.70E-04**	**1.27E+00**	**5.95E-05**	**9.74E-06**

W&S Composition for Truck Load Out Emissions

W&S Gas Component	Mole Fraction[a] (%)	Molecular Weight (lb/lb-mol)	Gas Weight (lb/lb-mol)	Weight Percent (wt%)
Methane	0.000	16.040	0.000	0.000
Ethane	4.732	30.070	1.423	2.476
Nitrogen	0.000	28.020	0.000	0.000
Water	0.000	18.015	0.000	0.000
Carbon Dioxide	0.224	43.990	0.098	0.171
Nitrous Oxide	0.000	44.020	0.000	0.000
Hydrogen Sulfide	1.018	34.060	0.347	0.603
Non-reactive, non-HA	5.974	---	1.868	3.250
Propane	27.635	44.100	12.187	21.203
Iso-butane	10.353	58.120	6.017	10.468
n-butane	25.191	58.120	14.641	25.473
i-pentane	8.741	72.150	6.307	10.972
n-pentane	9.278	72.150	6.694	11.647
Hexanes	3.874	100.210	3.882	6.754
Heptanes	2.680	100.200	2.685	4.671
Octanes	1.820	114.230	2.079	3.616
Nonanes	0.302	128.258	0.388	0.675
Decanes+	0.000	142.29	0.000	0.000
Reactive VOC	89.873	---	54.879	95.481
Benzene	0.325	78.110	0.254	0.441
Ethylbenzene	0.011	106.160	0.012	0.021
n-Hexane	3.334	100.210	3.341	5.813
Toluene	0.350	92.130	0.322	0.560
Xylenes	0.133	106.160	0.141	0.246
HAPs	4.153	---	4.070	7.082
Totals	**100.000**	---	**57.476**	**100.000**

[a] E&P Tanks Stream Data for W&S Gas mol %. E&P Tanks input data from Montana BLM (Laakso, 2010)

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions from Recompletion Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]				
		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	k $(s/12)^a$ $(W/3)^b$	k	1.5	0.15
		a	0.9	0.9
		b	0.45	0.45
E_{ext} = E (1 - P/365)				

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Road Traffic

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/well)	PM_{10} Emissions (tpy/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/well)	$PM_{2.5}$ Emissions (tons/ year/well)	$PM_{2.5}$ Emissions (tons/well)
Well Recompletion	Fuel Haul Truck	25	6	6	36	1	1.19	42.83	0.02	0.49	0.12	4.28	0.00	0.05
	Mud Haul Truck, Water Hauling	25	6	4	24	1	1.19	28.55	0.01		0.12	2.86	0.00	
	Rig Crew	5	6	51	306	1	0.58	176.46	0.09		0.06	17.65	0.01	
	Rig Mechanics	5	6	1	6	1	0.58	3.46	0.00		0.06	0.35	0.00	
	Co. Supervisor	5	6	20	120	1	0.58	69.20	0.03		0.06	6.92	0.00	
	Semi Completion, Unit Rig	42	6	1	6	1	1.50	9.02	0.00		0.15	0.90	0.00	
	Semi Fracing, Blender	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Semi Pumping/Tank Battery	25	6	6	36	1	1.19	42.83	0.02		0.12	4.28	0.00	
	Tubing Truck	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
	Haul Cementer, Pump Truck	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
	Haul Cementer, Cement Truck	25	6	3	18	1	1.19	21.42	0.01		0.12	2.14	0.00	
	Haul Completion,	25	6	3	18	1	1.19	21.42	0.01		0.12	2.14	0.00	
	Haul Service Tools	25	6	2	12	1	1.19	14.28	0.01		0.12	1.43	0.00	
	Haul Perforators Logging Truck	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Fracing, Tank	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Fracing, Pump	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Fracing, Chemical	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Fracing, Sand	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Fracing, Other	25	6	1	6	1	1.19	7.14	0.00		0.12	0.71	0.00	
	Haul Water Truck	25	6	50	300	1	1.19	356.93	0.18		0.12	35.69	0.02	
	Pickup Cementer, Engineer	5	6	2	12	1	0.58	6.92	0.00		0.06	0.69	0.00	
	Pickup Casing Crew	5	6	5	30	1	0.58	17.30	0.01		0.06	1.73	0.00	
	Pickup Completion, Pusher	5	6	5	30	1	0.58	17.30	0.01		0.06	1.73	0.00	
	Pickup Perforators, Engineer	5	6	2	12	1	0.58	6.92	0.00		0.06	0.69	0.00	
	Pickup Fracing, Engineer	5	6	1	6	1	0.58	3.46	0.00		0.06	0.35	0.00	
	Pickup Co. Supervisor	5	6	10	60	1	0.58	34.60	0.02		0.06	3.46	0.00	
	Pickup Miscellaneous Supplies	5	6	3	18	1	0.58	10.38	0.01		0.06	1.04	0.00	
	Pickup Roustabout Crew	5	6	4	24	1	0.58	13.84	0.01		0.06	1.38	0.00	
									Subtotal	**4.88E-01**				**4.88E-02**
								Total		**4.88E-01**				**4.88E-02**

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Oil Wells - Alternatives A, B, C, and D

Exhaust Emissions from Recompletion Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/Year	Miles Traveled/Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well)						(tons/vehicle type/well)						(tons/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
	Fuel Haul Truck	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Mud Haul Truck, Water Hauling	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
	Rig Crew	LDDT	40	51	2040	1	10.3979	0.4889	0.3980	0.0252	28.0950	12.3542	0.0052	0.0002	0.0002	0.0000	0.0140	0.0062							0.9	0.0000	0.0001
	Rig Mechanics	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Co. Supervisor	LDDT	40	20	800	1	4.0776	0.1917	0.1561	0.0099	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.0000	0.0000
	Semi Completion, Unit Rig	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Semi Fracing, Blender	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Semi Pumping/Tank Battery	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.0000	0.0000
	Tubing Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Pump Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Cementer, Cement Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Completion, Equip Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.0000	0.0000
	Haul Service Tools	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Haul Perforators Logging Truck	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
Well Recompletion	Haul Fracing, Tank	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.02	0.00	0.00	0.00	0.03	0.01	0.0	0.0000	0.0000
	Haul Fracing, Pump	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Chemical	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Sand	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Fracing, Other	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Haul Water Truck	HDDV	40	50	2000	1	11.9753	1.2134	1.0128	0.0582	7.5882	1.5608	0.0060	0.0006	0.0005	0.0000	0.0038	0.0008							1.7	0.0001	0.0001
	Pickup Cementer, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Pickup Completion Crew	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001							0.2	0.0000	0.0000
	Pickup Completion, Pusher	LDDT	40	5	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.0000	0.0000
	Pickup Perforators, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.0000	0.0000
	Pickup Fracing, Engineer	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.0000	0.0000
	Pickup Co. Supervisor	LDDT	40	10	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.0000	0.0000
	Pickup Miscellaneous Supplies	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.0000	0.0000
	Pickup Roustabout Crew	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.0000	0.0000
																		Subtotal	2.11E-02	1.61E-03	1.33E-03	7.87E-05	3.34E-02	1.30E-02	5.03E+00	1.63E-04	4.08E-04
																		Total	2.11E-02	1.61E-03	1.33E-03	7.87E-05	3.34E-02	1.30E-02	5.03E+00	1.63E-04	4.08E-04

Oil Wells - Alternatives A, B, C, and D

Venting Emissions from Well Completion Activities (applied to all wells drilled)

Gas Component	Mole Fraction	Molecular Weight	Gas Weight	Weight Percent	Weight	Emissions Mass Flow
	(%)	(lb/lb-mol)	(lb/lb-mol)	(wt%)	(lb/MMscf))	(ton/well)
Methane	65.450	16.040	10.498	42.544	18064.029	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.620	43.990	0.273	1.105	469.295	0.013
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000
Non-reactive, non-HAP	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
Heptanes	0.000	100.200	0.000	0.001	0.529	0.000
Octanes	0.000	114.230	0.000	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000
Reactive VOC	15.340	---	8.382	33.969		0.389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000
HAPs	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

Oil well natural gas analysis for Formation: Madison, Lease: Berry 11-4

Volume Flow:	900 SCF / bbl oil
BBL oil / day:	20 bbl oil / day
Completion activity duration:	3 days
Total Completion/Recompletion Volume Flow per Well	0.054 MMSCF/well

Assume: Gas density is 0.04246 lb/scf (19.26 g/scf).

Venting Emissions from Well Re-Completion Activities (applied to 5% of operating wells)

Gas Component	Mole Fraction	Molecular Weight	Gas Weight	Weight Percent	Weight	Emissions Mass Flow
	(%)	(lb/lb-mol)	(lb/lb-mol)	(wt%)	(lb/MMscf))	(ton/well)
Methane	65.450	16.040	10.498	42.544	18064.029	0.488
Ethane	15.330	30.070	4.610	18.681	7931.881	0.214
Nitrogen	3.260	28.020	0.913	3.702	1571.760	0.042
Water	0.000	18.015	0.000	0.000	0.000	0.000
Carbon Dioxide	0.620	43.990	0.273	1.105	469.295	0.013
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000
Non-reactive, non-HAP	84.660	---	16.294	66.031		0.757
Propane	7.890	44.100	3.479	14.101	5987.096	0.162
Iso-butane	1.370	58.120	0.796	3.227	1370.083	0.037
n-butane	3.360	58.120	1.953	7.914	3360.203	0.091
i-pentane	1.000	72.150	0.722	2.924	1241.472	0.034
n-pentane	1.040	72.150	0.750	3.041	1291.131	0.035
Hexanes	0.680	100.210	0.681	2.761	1172.521	0.032
Heptanes	0.000	100.200	0.000	0.001	0.529	0.000
Octanes	0.000	114.230	0.000	0.000	0.000	0.000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000
Reactive VOC	15.340	---	8.382	33.969		0.389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000
n-Hexane [3]	*0.680*	*100.210*	*0.681*	*2.761*	*1172.521*	*0.032*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000
HAPs	0.680	---	0.681	2.761		0.032
Totals	**100.000**	**---**	**24.676**	**100.000**		**1.146**

Oil Wells - Alternatives A, B, C, and D

Compressor Stations Emissions

Emission Factors for Natural Gas-Fired Compressors and Pumps

Compressor / Pump		Horse-Power Rating	Units	Emission Factors									
				NO_x[a]	PM_{10}[b]	SO_2[b]	CO[a]	VOC[a]	$PM_{2.5}$[b]	CO_2[c]	CH_4[c]	HCHO[b]	N_2O[c]
Compression Station	Lean Burn	300	gm/bhp-hr	1.00	0.044	0.001	2.00	0.70	0.044	134.9	2.5E-03	0.064	2.55E-04
			lb/MMBTU		3.84E-02	5.88E-04			3.84E-02	116.9	2.2E-03	5.52E-02	2.20E-04
Oil Pump at Well Head	Lean Burn	40	gm/bhp-hr	1.00	0.044	0.001	2.00	0.70	0.044	134.9	0.003	0.064	2.55E-04
			lb/MMBTU		3.84E-02	5.88E-04			3.84E-02	116.9	2.20E-03	5.52E-02	2.20E-04

[a] Source: assume compressors will comply with NSPS 40 CFR part 60 subpart JJJJ
[b] Source: EPA, AP-42 Section 3.2 Natural Gas Fired Reciprocating Engines
Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.
[c] EPA Mandatory GHG Reporting, Part 98, Subpart C, Tables C-1 and C-2.

Emission Estimations for Compressors and Pumps - All Years

Type of Compressors / Pumps	Rate (Hp/well)	Annual # of Wells in Production	Annual Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
Compression Station	7.5	1.00	7.5	8,760	0.07	0.00	0.00	0.14	0.05	0.00	9.8	0.00	0.00	0.00
Oil Pump at Well Head	40	1.00	40	8,760	0.39	0.02	0.00	0.77	0.27	0.02	52.1	0.00	0.02	0.00
				Total	**4.59E-01**	**2.03E-02**	**3.11E-04**	**9.17E-01**	**3.21E-01**	**2.03E-02**	**6.19E+01**	**1.17E-03**	**2.92E-02**	**1.17E-04**

HCHO = Formaldehyde
Compression rate of 5 compressors (300 hp each) per 200 wells based on BLM survey (Laakso, 2010)
Typical oil well head pump of 40 hp per BLM survey (Laakso, 2010)

Compressor Station Fugitives
Fugitive Emissions from Equipment Leaks

Well Equipment Component	TOC Emission Factor							
	Gas		Light Oil >20º API		Heavy Oil <20º API		Water/Oil	
	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)
valves	4.50E-03	9.92E-03	2.50E-03	5.51E-03	8.40E-06	1.85E-05	9.80E-05	2.16E-04
pump seals	2.40E-03	5.29E-03	1.30E-02	2.87E-02	3.20E-05	7.05E-05	2.40E-05	5.29E-05
others	8.80E-03	1.94E-02	7.50E-03	1.65E-02	3.20E-05	7.05E-05	1.40E-02	3.09E-02
connectors	2.00E-04	4.41E-04	2.10E-04	4.63E-04	7.50E-06	1.65E-05	1.10E-04	2.43E-04
flanges	3.90E-04	8.60E-04	1.10E-04	2.43E-04	3.90E-07	8.60E-07	2.90E-06	6.39E-06
open-ended lines	2.00E-03	4.41E-03	1.40E-03	3.09E-03	1.40E-04	3.09E-04	2.50E-04	5.51E-04

Source: EPA-453/R-95-017 Protocol for Equipment Leak Emission Estimates, November 1995
Table 2-4 , Oil and Gas Production Operations Average Estimation Factors
"Other" category includes compressor seals, pressure relief valves, diaphragms, drains, dump arms, hatches, instruments, meters, polished rods and vents

From Montana BLM provided NG analysis

VOC Wt% =	33.97
CO2 Wt% =	1.11
CH4 Wt% =	42.54
N2O Wt% =	0.00

Oil Wells - Alternatives A, B, C, and D

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service	Emission factor (lb/hr)	Ave. # in Liquid service	Emission factor (lb/hr)	Ave. # in Water/Oil Service	Emission factor (lb/hr)	TOC emissions per well (lb/hr)	VOC emissions per well (lb/hr)	CO_2 emissions per well (lb/hr)	CH_4 emissions per well (lb/hr)
valves	0.175	0.0099	0	0.0055	0	0.0002	0.002	0.001	0.000	0.001
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.000	0.000	0.000	0.000
others	0.000	0.0194	0	0.0165	0	0.0309	0.000	0.000	0.000	0.000
connectors	0.250	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.600	0.0009	0	0.0002	0	0.0000	0.001	0.000	0.000	0.000
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
						TOTAL emissions/well/hr =	0.002	0.001	0.000	0.001

Number of components provided by Montana BLM FO personnel (Laakso, 2010)

Annual Emissions from Equipment Leaks Per Well

Year	Number of Producing Wells	Operating Hours	VOC emissions (lb/yr)	VOC emissions (tpy)	CO_2 emissions (lb/yr)	CO2 emissions (tpy)	CH_4 emissions (lb/yr)	CH4 emissions (tpy)
Year 20	1	8760	7.03	**3.51E-03**	0.23	**1.14E-04**	8.80	**4.40E-03**

Oil Wells - Alternatives A, B, C, and D

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ for U*>Ut*; F AP-42 Section 13.2.5.3 Equation 3

Friction Velocity U* (m/s) = $0.053\ U_{10}^*$ AP-42 Section 13.2.5.3 Equation 4

P = Erosion Potential (gm/m²/yr) M = Disturbed area (m²)
U* = Friction velocity (m/s) N = # of disturbances
U_t = threshold velocity (m/s) k = 0.5 for PM_{10}
U10 = fastest wind speed (m/s) k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Scoria
U_t roads/pipelines = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material

Construction Wind Erosion Emissions - Based on Peak Wells Drilled each Alternative

	Fastest Mile (U_{10}) (m/s)	Max. Friction Velocity (U*) (m/s)	Well Erosion Potential (P) (g/m²/yr)	Road Erosion Potential (P) (g/m²/yr)	Peak # of Wells Drilled per year	Average Disturbed acres per well [a]	Disturbed Area (M) (m²)	Number of Disturbances (N)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	3.00	12144.98	1.00	9.76E-03	1.46E-03
Road and Pipeline Construction	26.08	1.38		1.46	1.00	1.50	6072.49	1.00	4.88E-03	7.32E-04
								TOTAL	**1.46E-02**	**2.20E-03**

[a] Number of acres per well pad provided by data in Billings Field Office Resource Management Plan.

Oil Wells - Alternatives A, B, C, and D

Emissions for Road and Well Pad Reclamation

Type	Equipment/Vehicle			Total Miles Worked on/Day	# of Operating Hours/Day
	Type	Fuel	Capacity (hp)		
Roads	Heavy Equipment	Diesel	80	6	10
	Commuting Vehicle	Gasoline	225	6	1.5
Wells[a]	Heavy Equipment	Diesel	100	N/A	10
	Commuting Vehicle	Gasoline	225	6	2

[a] Assume 0.5 day with a blade and tractor each for reseeding per well at time of abandonment.
Source: values from SEIS

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.250
Number of Roads Reclaimed Annually Per Well	0.153
Annual Miles of Roads Reclaimed Per Well	0.038
Number of wells reclaimed (per well)	0.153

Reclamation rates derived from RMP (total Federal and non-Federal)

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.038	6	0.0064	0.0639
		Total	**0.0639**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\,S^2$	5	0.765
$PM_{2.5}$	$E = (0.031)(0.04)\,S^{2.5}$	5	0.069

[a] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclamation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.038	5	0.192	0.765	**7.33E-05**	0.069	**6.64E-06**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

[a] Emissions of $PM_{2.5}$ were assumed to be the same as those for PM_{10}.
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.038	0.4238	0.0720	0.0197	0.4106	0.0629	**8.12E-06**	**1.38E-06**	**3.77E-07**	**7.87E-06**	**1.20E-06**	**1.34E-06**	**2.08E-03**	**1.87E-08**	**2.05E-08**

Oil Wells - Alternatives A, B, C, and D

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10} Em. Factor (lb/VMT)[a]	PM_{10} (tpy/well)	$PM_{2.5}$ Em. Factor (lb/VMT)[a]	$PM_{2.5}$ (tpy/well)
Road Reclamation	Pickup Truck	40	6	0.0064	0.0383	0.535	**1.03E-05**	0.053	**1.02E-06**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclamation Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclamation Vehicles: Road Traffic

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	40	0.0064	0.2556	**6.51E-07**	**3.06E-08**	**2.49E-08**	**1.58E-09**	**1.76E-06**	**7.74E-07**	**1.15E-04**	**5.63E-10**	**1.49E-08**

Estimation of Annual Days and Hours for Well Reclamation

Equipment	# of Wells Reclaimed/Year	# of Hours/Day	Annual # of Days	Annual Hours of Operation
Grader	0.153	10	0.153	1.53

Assume grader works 0.5 day as a blade and tractor each per well.

Oil Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions Estimation for Grader: Well Reclamation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	0.9200	5	4.600	0.765	**1.76E-03**	0.069	**1.59E-04**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Reclamation	Grader	100	0.9200	0.5297	0.0900	0.0246	0.5132	0.0786	**2.44E-04**	**4.14E-05**	**1.13E-05**	**2.36E-04**	**3.61E-05**	**6.43E-05**	**6.09E-02**	**1.01E-06**	**6.14E-07**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	40	0.1533	6.1333	0.535	**1.64E-03**	0.053	**1.64E-04**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions								
						(tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	40	0.1533	6.1333	**1.56E-05**	**7.35E-07**	**5.98E-07**	**3.79E-08**	**4.22E-05**	**1.86E-05**	**2.77E-03**	**1.35E-08**	**3.58E-07**

Oil Wells - Alternatives A, B, C, and D

Emissions for Gas Dehydration

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
lb/MMSCF	100	7.60	0.60	84	5.50	5.7	120000	2.3	0.075	2.2
lb/MMBTU	0.098	0.007	0.001	0.082	0.005	0.006	117.647	0.002	0.000	0.002

Source: EPA, AP-42 Section 1.4 Natural Gas Combustion

Emission Estimate for Dehydrator Heaters

Operating Hours per Year[a]	Dehydrator Heater Size MMBtu/Hour	Fuel Usage MMCF/Year	Number of Dehydrator Stations / Well	Emissions (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**5.66E-05**	**4.30E-06**	**3.40E-07**	**4.75E-05**	**3.11E-06**	**3.23E-06**	**6.79E-02**	**1.30E-06**	**4.24E-08**	**1.25E-06**

Values from Montana BLM (Laakso, 2010)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton/MMscf)	CH_4 Emissions (tpy/well)	VOC Emission Factor (ton/MMscf)	VOC Emissions (tpy/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (tpy/well)
6.57	0.011	**7.04E-02**	0.016	**1.05E-01**	0.002	**1.30E-02**

Gas analysis and dehydration process information provided by Montana BLM (Laakso, 2010)
Emission factor include emissions from dehy/regenerator still vents (no control) and flash tank emissions (no control).
Assumed 100% of gas production flows through dehydrators at sales compressor station (Laakso, 2010)

The following Compressor Station assumptions were used with oil Well specific gas composition analysis to derive dehydrator emissions:
per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compres ---
gas is saturated	---		---	Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas		---	Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Natural Gas Wells - Alternatives A, B, C, and D

Alternatives A, B, C, and D, B, C, and D input parameters for calculating Natural Gas wells emissions

Maximum Annual Wells Drilled - Federal (RMP estimate)	1	Maximum Annual Wells Drilled - Non-Federal (RMP estimate)	4
Federal Producing Wells - RMP Year 20	20	Non-Federal Producing Wells - RMP Year 20	80
Average Gas Production Per Well (MCFD)	40	Average Gas Production Per Well (MCFD)	40

* 100% full RMP estimates for Federal, full RMP estimates (100%) for non-Federal

Federal NG Wells Summaries

Total Annual Emissions from Federal NG Wells - RMP Year - Alternatives A, B, C, and D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.06	0.01	---	---	---	---	---	---	---	---	---	---
Heavy Equipment Combustive Emissions	0.01	0.01	0.19	0.05	1.24	0.07	0.01	241.19	0.00	0.00	242.08	219.67
Commuting Vehicles - Construction	2.48	0.25	0.05	0.00	0.06	0.02	0.00	13.35	0.00	0.00	13.64	12.38
Wind Erosion	0.02	0.00	---	---	---	---	---	---	---	---	---	---
Completion Venting	---	---	---	---	---	0.02	0.00	0.01	2.27	0.00	47.62	43.21
Sub-total: Construction	**2.57**	**0.27**	**0.24**	**0.05**	**1.30**	**0.11**	**0.01**	**254.54**	**2.27**	**0.00**	**303.34**	**275.27**
Well Workover Operations - Fugitive Dust	0.47	0.05	---	---	---	---	---	---	---	---	---	---
Well Workover Operations - On-site Exhaust	0.01	0.01	0.12	0.05	1.03	0.06	0.01	210.43	0.00	0.00	211.20	191.65
Well Workover Operations - On-road Exhaust	0.00	0.00	0.01	0.00	0.02	0.01	0.001	2.48	0.00	0.00	2.55	2.31
Well Visits for Inspection & Repair - Operations	0.70	0.07	0.00	0.00	0.07	0.00	0.000	1.37	0.00	0.00	1.53	1.39
Wellhead and Compressor Station Fugitives	---	---	---	---	---	0.05	0.01	0.02	7.07	0.00	148.59	134.84
Compression	0.18	0.18	4.13	0.00	8.27	2.89	0.29	557.85	0.01	0.00	558.40	506.71
Station Visits - Operations	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.14	0.13
Dehydrators	0.00	0.00	0.00	0.00	0.00	0.01	0.00	3.02	4.54	0.00	98.27	89.18
Sub-total: Operations	**1.44**	**0.32**	**4.27**	**0.05**	**9.39**	**3.02**	**0.30**	**775.31**	**11.62**	**0.00**	**1,020.68**	**926.21**
Road Maintenance	0.24	0.03	0.04	0.001	0.02	0.00	0.000	5.30	0.00	0.00	5.32	4.83
Sub-total: Maintenance	**0.24**	**0.03**	**0.04**	**0.001**	**0.02**	**0.00**	**0.000**	**5.295**	**0.000**	**0.00**		**4.83**
Road Reclamation	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.31	0.28
Well Reclamation	0.59	0.07	0.04	0.00	0.04	0.01	0.00	8.99	0.00	0.00	9.05	8.21
Sub-total: Reclamation	**0.61**	**0.07**	**0.04**	**0.0016**	**0.04**	**0.009**	**0.0009**	**9.3048**	**0.0001**	**0.0002**	**9.3591**	**8.4928**
Total Emissions	**4.86**	**0.68**	**4.59**	**0.10**	**10.75**	**3.14**	**0.31**	**1,044.45**	**13.89**	**0.01**	**1,333.39**	**1,214.80**

Natural Gas Wells - Alternatives A, B, C, and D

Non-Federal NG Wells Summaries

Total Annual Emissions from Non-Federal NG Wells - RMP Year - Alternatives A, B, C, and D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs	CO_2	CH_4	N_2O	CO_{2eq}	CO2eq metric tons
Well Pad Construction - Fugitive Dust	0.25	0.02	—	—	—	—	—	—	—	—	—	—
Heavy Equipment Combustive Emissions	0.06	0.06	1.05	0.19	4.96	0.27	0.03	964.28	0.01	0.00	965.34	875.99
Commuting Vehicles - Construction	9.90	1.00	0.20	0.00	0.24	0.08	0.01	53.39	0.00	0.00	53.72	48.75
Wind Erosion	0.07	0.01	—	—	—	—	—	—	—	—	—	—
Completion Venting	—	—	—	—	—	0.07	0.00	0.03	9.07	0.00	190.49	172.85
Sub-total: Construction	**10.28**	**1.10**	**1.25**	**0.19**	**5.20**	**0.42**	**0.04**	**1,017.70**	**9.08**	**0.00**	**1,209.54**	**1,097.59**
Well Workover Operations - Fugitive Dust	1.89	0.19	—	—	—	—	—			—	—	—
Well Workover Operations - On-site Exhaust	0.60	0.59	10.62	0.18	3.57	0.77	0.08	840.60	0.01	0.01	843.82	765.72
Well Workover Operations - On-road Exhaust	0.00	0.00	0.04	0.00	0.08	0.03	0.003	9.92	0.00	0.00	10.20	9.25
Well Visits for Inspection & Repair - Operations	2.78	0.28	0.01	0.00	0.27	0.01	0.001	5.47	0.00	0.00	6.12	5.55
Wellhead and Compressor Station Fugitives	—	—	—	—	—	0.22	0.02	0.10	28.30	0.00	594.37	539.36
Compression	0.73	0.73	16.54	0.01	33.07	11.58	1.16	2,231.40	0.04	0.00	2233.59	2026.85
Station Visits - Operations	0.33	0.03	0.00	0.00	0.01	0.00	0.00	0.55	0.00	0.00	0.57	0.52
Dehydrators	0.00	0.00	0.01	0.00	0.01	0.03	0.01	12.07	18.14	0.00	393.09	356.71
Sub-total: Operations	**6.34**	**1.82**	**27.23**	**0.19**	**37.01**	**12.63**	**1.27**	**3,100.10**	**46.49**	**0.02**	**4,081.76**	**3,703.96**
Road Maintenance	0.96	0.10	0.17	0.005	0.07	0.02	0.002	21.18	0.00	0.00	21.29	19.32
Sub-total: Maintenance	**0.96**	**0.10**	**0.17**	**0.005**	**0.07**	**0.02**	**0.002**	**21.181**	**0.000**	**0.00**		**19.32**
Road Reclamation	0.10	0.01	0.01	0.00	0.01	0.00	0.00	1.24	0.00	0.00	1.25	1.14
Well Reclamation	2.36	0.26	0.15	0.01	0.17	0.04	0.00	35.98	0.00	0.00	36.19	32.84
Sub-total: Reclamation	**2.46**	**0.27**	**0.15**	**0.0065**	**0.17**	**0.037**	**0.0037**	**37.2192**	**0.0006**	**0.0007**	**37.4362**	**33.9712**
Total Emissions	20.04	3.30	28.81	0.39	42.45	13.11	1.31	4,176.20	55.58	0.02	5,328.74	4,854.83

Natural Gas Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions From Well Pad Construction

Fugitive Dust from Heavy Construction Operations			
INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors*, Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Emissions Estimation for Construction Activities

Area Disturbed for Oil Wells	Avg. Disturbed Acres per well[a]	Construction Days	Total # of Wells	Total Disturbed Acres	(lbs/well)		(tpy/well)	
					PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Improved Road	1.5	3	1	1.5	3.30E+01	3.30E+00	1.65E-02	1.65E-03
Well Pad and other structures	4.0	3	1	4.0	8.80E+01	8.80E+00	4.40E-02	4.40E-03
Field Compressor Station	0.04	6	1	0.04	1.83E+00	1.83E-01	9.13E-04	9.13E-05
Sales Compressor Station	0.01	6	1	0.01	3.04E-01	3.04E-02	1.52E-04	1.52E-05
			Total		**123**	**12.31**	**6.16E-02**	**6.16E-03**

[a] Road and well pad disturbance provided by data in Billings Field Office RMP; average disturbed area data for new NG wells shown in SEIS and for Compressor Stations provided by Montana BLM (Laakso, 2010)

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Federal)

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)									Equipment Category
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	4.37	0.34	0.12	1.52	0.35	0.33	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	4.85	0.57	0.13	3.94	0.50	0.55	594.65	0.008	0.006	Motor Grader

Source: EPA NONROADS 2008a

NOTE: Use emission factors for 2008 for all project years = conservative estimate of fleet turnover

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Construction Equipment (using 2008 emission factors)

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions													
									(lbs/equipment type/well)					(tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.4748	0.0000	0.0000
Well Pad	Blade	175	1	75	10	3	30	1	42.10	4.95	1.13	34.20	4.34	0.02	0.00	0.00	0.02	0.00	0.00	2.5809	0.0000	0.0000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.7530	0.0000	0.0000
													Subtotal	5.33E-02	5.46E-03	1.44E-03	3.39E-02	5.03E-03	6.30E-03	6.81E+00	8.64E-05	6.93E-05

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	3.50	0.022	0.12	3.70	0.14	0.02	589.10	0.006	0.006
75 to 100	0.30	0.015	0.11	3.70	0.14	0.02	589.10	0.006	0.006
100 to 175	0.30	0.015	0.11	3.70	0.14	0.02	530.10	0.005	0.006
175 to 300	0.30	0.015	0.11	2.60	0.14	0.02	530.18	0.004	0.006
300 to 600	0.30	0.015	0.11	2.60	0.14	0.02	530.25	0.004	0.006
600 to 750	0.30	0.015	0.11	2.60	0.14	0.02	530.28	0.004	0.006
>750	0.50	0.022	0.10	2.60	0.14	0.02	529.92	0.006	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. EPA NONROADS 2008a (Year 2008) for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/ Day	# of Operating Days/ Well	# of Operating Hours/ Well	# of Wells	Max. Annual Emissions													
									(lbs/equipment type/well)					(tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	213	11	81	1,849	100	0.11	0.01	0.04	0.92	0.05	0.01	188.53	0.00	0.00
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	5	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.22	0.00	0.00
	Generators	150	2	75	24	8	192	1	29	1	11	352	13	0.01	0.00	0.01	0.18	0.01	0.00	25.24	0.00	0.00
Well Completion & Testing	Main Deck	400	1	50	11	5	55	1	7	0	3	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.43	0.00	0.00
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	13	0	0.00	0.00	0.00	0.01	0.00	0.00	0.93	0.00	0.00
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.05	0.00	0.00
	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)[b]	# of Operating Hours/ Day	# of Operating Days/ Well	# of Operating Hours/ Well	# of Wells														
	Field Generators for Pumps & Lighting	55	1	75	12	3	36	1	11.46	0.07	0.38	12.11	0.46	5.73E-03	3.60E-05	1.90E-04	6.06E-03	2.29E-04	3.60E-05	9.64E-01	1.05E-05	9.91E-06
													Subtotal	1.38E-01	6.64E-03	5.06E-02	1.21E+00	6.19E-02	6.64E-03	2.34E+02	1.80E-03	2.67E-03
													Total	1.91E-01	1.21E-02	5.20E-02	1.24E+00	6.69E-02	1.29E-02	2.41E+02	1.89E-03	2.74E-03

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust Emissions from Well Pad Construction Heavy Equipment and Drilling Equipment (Non-Federal)

Emission Factors for Construction Equipment

Equipment	Emission Factors (g/hp-hr)									Equipment Category
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]	
Dozer - 175 Hp	4.37	0.34	0.12	1.52	0.35	0.33	535.76	0.005	0.006	Track-Type Tractor
Blade - 150 Hp	4.85	0.57	0.13	3.94	0.50	0.55	594.65	0.008	0.006	Motor Grader

Source: EPA NONROADS 2008a

NOTE: Use emission factors for 2008 for all project years = conservative estimate of fleet turnover

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Construction Equipment (using 2008 emission factors)

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Improved & Two-Track Road	Blade	150	1	75	10	2	20	1	24.06	2.83	0.64	19.54	2.48	0.01	0.00	0.00	0.01	0.00	0.00	1.4748	0.0000	0.0000
Well Pad	Blade	175	1	75	10	3	30	1	42.10	4.95	1.13	34.20	4.34	0.02	0.00	0.00	0.02	0.00	0.00	2.5809	0.0000	0.0000
	Dozer	175	1	80	10	3	30	1	40.46	3.15	1.11	14.07	3.24	0.02	0.00	0.00	0.01	0.00	0.00	2.7530	0.0000	0.0000
													Subtotal	5.33E-02	5.46E-03	1.44E-03	3.39E-02	5.03E-03	6.30E-03	6.81E+00	8.64E-05	6.93E-05

Exhaust Emission Factors for Diesel Powered Bore/Drill Rig Engines

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOCs	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
Year 2018									
50 to 75	4.55	0.41	0.12	2.13	0.42	0.40	589.10	0.006	0.006
75 to 100	3.75	0.42	0.11	2.03	0.42	0.41	589.10	0.006	0.006
100 to 175	3.57	0.27	0.10	1.00	0.31	0.26	530.10	0.005	0.006
175 to 300	3.37	0.23	0.10	0.83	0.28	0.22	530.18	0.004	0.006
300 to 600	3.61	0.21	0.10	1.06	0.26	0.21	530.25	0.004	0.006
600 to 750	3.61	0.22	0.10	1.25	0.25	0.21	530.28	0.004	0.006
>750	5.13	0.26	0.10	1.29	0.37	0.25	529.92	0.006	0.006

Source: EPA NONROADS 2008a - Year 2018 accounts for mixture of Tier 1-3 engines

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Industrial Engines

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	# of Wells	Max. Annual Emissions (lbs/equipment type/well)					Max. Annual Emissions (tons/equipment type/well)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Rig-up, Drilling, and Rig-down	Main Deck	400	3	70	24	16	384	1	356	16	73	1,849	100	0.18	0.01	0.04	0.92	0.05	0.01	188.4150	0.0020	0.0022
	Auxiliary Pump	200	1	80	8	15	120	1	13	1	5	110	6	0.01	0.00	0.00	0.06	0.00	0.00	11.2223	0.0001	0.0001
	Generators	150	2	75	24	8	192	1	29	1	11	352	13	0.01	0.00	0.01	0.18	0.01	0.00	25.2427	0.0002	0.0003
Well Completion & Testing	Main Deck	400	1	50	11	5	55	1	7	0	3	63	3	0.00	0.00	0.00	0.03	0.00	0.00	6.4295	0.0000	0.0001
	Auxiliary Pump	125	1	80	8	2	16	1	1	0	0	9	0	0.00	0.00	0.00	0.00	0.00	0.00	0.9351	0.0000	0.0000
	Power Swivel	150	1	75	8	2	16	1	1	0	0	15	1	0.00	0.00	0.00	0.01	0.00	0.00	1.0518	0.0000	0.0000
	Equipment Type	**Capacity (hp)**	**# of Units**	**Avg. Load Factor (%)[b]**	**# of Operating Hours/ Day**	**# of Operating Days/ Well**	**# of Operating Hours/ Well**	**# of Wells**														
	Field Generators for Pumps & Lighting	55	1	75	12	3	36	1	11.46	0.07	0.38	12.11	0.46	0.01	0.00	0.00	0.01	0.00	0.00	0.9643	0.0000	0.0000
													Subtotal	2.09E-01	9.13E-03	4.62E-02	1.21E+00	6.19E-02	9.13E-03	2.34E+02	2.39E-03	2.67E-03
													Total	2.62E-01	1.46E-02	4.76E-02	1.24E+00	6.69E-02	1.54E-02	2.41E+02	2.48E-03	2.74E-03

Natural Gas Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k\,(s/12)^a\,(W/3)^b$	k	1.5	0.15
		a	0.9	0.9
		b	0.45	0.45
E_{ext} = E (1 - P/365)				

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Road Traffic - All Project Years

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle/ well)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle/ well)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
Improved & Two-Track Road	Semi Trucks	42	10	47	470	1	1.50	706.23	0.35	0.362	0.15	70.62	0.04	0.036
	Pickup Trucks	5	10	3	30	1	0.58	17.30	0.01		0.06	1.73	0.00	
Well Pad	Semi Trucks	42	10	5	50	1	1.50	75.13	0.04	0.049	0.15	7.51	0.00	0.005
	Pickup Trucks	5	10	4	40	1	0.58	23.07	0.01		0.06	2.31	0.00	
Other Construction Activities	Semi Trucks	42	10	2	20	1	1.50	30.05	0.02	0.030	0.15	3.01	0.00	0.003
	Haul Trucks	25	10	2	20	1	1.19	23.80	0.01		0.12	2.38	0.00	
	Pickup Trucks	5	10	1	10	1	0.58	5.77	0.00		0.06	0.58	0.00	
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	42	10	44	440	1	1.50	661.15	0.33	0.791	0.15	66.12	0.03	0.079
	Fuel Haul Truck	25	10	6	60	1	1.19	71.39	0.04		0.12	7.14	0.00	
	Mud Haul Truck, Water Hauling	25	10	4	40	1	1.19	47.59	0.02		0.12	4.76	0.00	
	Rig Crew	5	10	51	510	1	0.58	294.10	0.15		0.06	29.41	0.01	
	Rig Mechanics	5	10	2	20	1	0.58	11.53	0.01		0.06	1.15	0.00	
	Co. Supervisor	5	10	20	200	1	0.58	115.33	0.06		0.06	11.53	0.01	
	Tool Pusher	25	10	8	80	1	1.19	95.18	0.05		0.12	9.52	0.00	
	Mud Logger	25	10	6	60	1	1.19	71.39	0.04		0.12	7.14	0.00	
	Mud Engineer	25	10	15	150	1	1.19	178.46	0.09		0.12	17.85	0.01	
	Logger, Engr Truck	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Drill Bit Delivery	25	10	2	20	1	1.19	23.80	0.01		0.12	2.38	0.00	
Well Completion & Testing (continued below)	Semi Casing Haulers	42	10	6	60	1	1.50	90.16	0.05	0.118	0.15	9.02	0.00	0.012
	Semi Completion, Unit Rig	42	10	1	10	1	1.50	15.03	0.01		0.15	1.50	0.00	
	Semi Fracing, Blender	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Semi Pumping/Tank Battery	25	10	6	60	1	1.19	71.39	0.04		0.12	7.14	0.00	
	Tubing Truck	25	10	2	20	1	1.19	23.80	0.01		0.12	2.38	0.00	
	Haul Cementer, Pump Truck	25	10	2	20	1	1.19	23.80	0.01		0.12	2.38	0.00	
									Subtotal	**1.35E+00**				**1.35E-01**

Natural Gas Wells - Alternatives A, B, C, and D

Emission Estimations for Road Traffic - All Project Years (continued)

Construction Site Destination	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/vehicle type)	PM_{10} Emissions (tons/ vehicle type/well)	PM_{10} Emissions (tons/well)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/vehicle type)	$PM_{2.5}$ Emissions (tons/ vehicle type/well)	$PM_{2.5}$ Emissions (tons/well)
	Haul Cementer, Cement Truck	25	10	3	30	1	1.19	35.69	0.02		0.12	3.57	0.00	
	Haul Completion,	25	10	3	30	1	1.19	35.69	0.02		0.12	3.57	0.00	
	Haul Service Tools	25	10	2	20	1	1.19	23.80	0.01		0.12	2.38	0.00	
	Haul Perforators Logging Truck	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Anchor, Installation	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Anchor, Testing	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Fracing, Tank	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Fracing, Pump	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Fracing, Chemical	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Fracing, Sand	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Fracing, Other	25	10	1	10	1	1.19	11.90	0.01		0.12	1.19	0.00	
	Haul Welders	25	10	6	60	1	1.19	71.39	0.04		0.12	7.14	0.00	
Well Completion & Testing (continued from above)	Haul Water Truck	25	10	150	1500	1	1.19	1,784.64	0.89	1.121	0.12	178.46	0.09	0.112
	Pickup Cementer, Engineer	5	10	2	20	1	0.58	11.53	0.01		0.06	1.15	0.00	
	Pickup Casing Crew	5	10	2	20	1	0.58	11.53	0.01		0.06	1.15	0.00	
	Pickup Completion Crew	5	10	5	50	1	0.58	28.83	0.01		0.06	2.88	0.00	
	Pickup Completion, Pusher	5	10	5	50	1	0.58	28.83	0.01		0.06	2.88	0.00	
	Pickup Perforators, Engineer	5	10	2	20	1	0.58	11.53	0.01		0.06	1.15	0.00	
	Pickup Fracing, Engineer	5	10	1	10	1	0.58	5.77	0.00		0.06	0.58	0.00	
	Pickup Co. Supervisor	5	10	10	100	1	0.58	57.67	0.03		0.06	5.77	0.00	
	Pickup Miscellaneous Supplies	5	10	3	30	1	0.58	17.30	0.01		0.06	1.73	0.00	
	Pickup Roustabout Crew	5	10	4	40	1	0.58	23.07	0.01		0.06	2.31	0.00	
									Subtotal	**1.12E+00**				**1.12E-01**
								Total		**2.47E+00**				**2.47E-01**

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust Emissions from Construction and Drilling Support Vehicles

Emission Factors for Commuting Vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O^a
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well)						Emissions (tons/vehicle type/well)					
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC
Improved & Two-Track Road	Semi Trucks	HDDV	40	47	1880	1	11.2568	1.1406	0.9520	0.0547	7.1329	1.4672	0.0056	0.0006	0.0005	0.0000	0.0036	0.0007
	Pickup Trucks	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004
Well Pad	Semi Trucks	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001
	Pickup Trucks	LDDT	40	4	160	1	0.8155	0.0383	0.0312	0.0020	2.2035	0.9690	0.0004	0.0000	0.0000	0.0000	0.0011	0.0005
Other Construction Activities	Semi Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000
	Haul Trucks	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000
	Pickup Trucks	LDDT	40	1	40	1	0.2039	0.0096	0.0078	0.0005	0.5509	0.2422	0.0001	0.0000	0.0000	0.0000	0.0003	0.0001

Construction Site Destination	Vehicle Type	Emissions (tons/well)								
		NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Improved & Two-Track Road	Semi Trucks	0.006	0.001	0.000	0.000	0.004	0.001	1.6409	0.000077	0.000092
	Pickup Trucks							0.0542	0.000000	0.000007
Well Pad	Semi Trucks	0.001	0.000	0.000	0.000	0.001	0.001	0.1746	0.000008	0.000010
	Pickup Trucks							0.0722	0.000000	0.000009
Other Construction Activities	Semi Trucks	0.001	0.000	0.000	0.000	0.001	0.000	0.0698	0.000003	0.000004
	Haul Trucks							0.0698	0.000003	0.000004
	Pickup Trucks							0.0181	0.000000	0.000002
Subtotal		**7.52E-03**	**7.18E-04**	**5.98E-04**	**3.46E-05**	**6.45E-03**	**1.84E-03**	**2.10E+00**	**9.21E-05**	**1.28E-04**

Natural Gas Wells - Alternatives A, B, C, and D

Combustive Emissions Estimation Road Traffic

Construction Site Destination	Vehicle Type	Vehicle Class	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells	Emissions (lbs/vehicle type/well) NO_x	(lbs/vehicle type/well) PM_{10}	(lbs/vehicle type/well) $PM_{2.5}$	(lbs/vehicle type/well) SO_2	(lbs/vehicle type/well) CO	(lbs/vehicle type/well) VOC	(tons/vehicle type/well) NO_x	(tons/vehicle type/well) PM_{10}	(tons/vehicle type/well) $PM_{2.5}$	(tons/vehicle type/well) SO_2	(tons/vehicle type/well) CO	(tons/vehicle type/well) VOC	(tons/well) NO_x	(tons/well) PM_{10}	(tons/well) $PM_{2.5}$	(tons/well) SO_2	(tons/well) CO	(tons/well) VOC	(tons/well) CO_2	(tons/well) CH_4	(tons/well) N_2O
Rig-up, Drilling, and Rig-down	Semi Rig Transport, Drill Rig	HDDV	40	44	1760	1	10.5383	1.0678	0.8913	0.0512	6.6776	1.3735	0.0053	0.0005	0.0004	0.0000	0.0033	0.0007	0.02	0.00	0.00	0.00	0.03	0.01	1.5	0.000072	0.000086
	Fuel Haul Truck	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.000010	0.000012
	Mud Haul Truck, Water Hauling	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.000007	0.000008
	Rig Crew	LDDT	40	51	2040	1	10.3979	0.4889	0.3980	0.0252	28.0950	12.3542	0.0052	0.0002	0.0002	0.0000	0.0140	0.0062							0.9	0.000004	0.000119
	Rig Mechanics	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Co. Supervisor	LDDT	40	20	800	1	4.0776	0.1917	0.1561	0.0099	11.0176	4.8448	0.0020	0.0001	0.0001	0.0000	0.0055	0.0024							0.4	0.000002	0.000047
	Tool Pusher	LDDT	40	8	320	1	1.6310	0.0767	0.0624	0.0040	4.4071	1.9379	0.0008	0.0000	0.0000	0.0000	0.0022	0.0010							0.1	0.000001	0.000019
	Mud Logger	LDDT	40	6	240	1	1.2233	0.0575	0.0468	0.0030	3.3053	1.4534	0.0006	0.0000	0.0000	0.0000	0.0017	0.0007							0.1	0.000001	0.000014
	Mud Engineer	LDDT	40	15	600	1	3.0582	0.1438	0.1171	0.0074	8.2632	3.6336	0.0015	0.0001	0.0001	0.0000	0.0041	0.0018							0.3	0.000001	0.000035
	Logger, Engr Truck	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Drill Bit Delivery	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.000000	0.000005
Well Completion & Testing	Semi Casing Haulers	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001	0.03	0.00	0.00	0.00	0.02	0.01	0.2	0.000010	0.000012
	Semi Completion, Unit Rig	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Semi Fracing, Blender	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Semi Pumping/Tank Battery	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.000010	0.000012
	Tubing Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Haul Cementer, Pump Truck	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Haul Cementer, Cement Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000005	0.000006
	Haul Completion, Equip Truck	HDDV	40	3	120	1	0.7185	0.0728	0.0608	0.0035	0.4553	0.0937	0.0004	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000005	0.000006
	Haul Service Tools	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.000000	0.000005
	Haul Perforators Logging Truck	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Anchor, Installation	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Anchor, Testing	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Fracing, Tank	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Fracing, Pump	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Fracing, Chemical	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Fracing, Sand	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Fracing, Other	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Haul Welders	HDDV	40	6	240	1	1.4370	0.1456	0.1215	0.0070	0.9106	0.1873	0.0007	0.0001	0.0001	0.0000	0.0005	0.0001							0.2	0.000010	0.000012
	Haul Water Truck	HDDV	40	150	6000	1	35.9259	3.6402	3.0384	0.1746	22.7646	4.6825	0.0180	0.0018	0.0015	0.0001	0.0114	0.0023							5.2	0.000245	0.000293
	Pickup Cementer, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.000000	0.000005
	Pickup Casing Crew	HDDV	40	2	80	1	0.4790	0.0485	0.0405	0.0023	0.3035	0.0624	0.0002	0.0000	0.0000	0.0000	0.0002	0.0000							0.1	0.000003	0.000004
	Pickup Completion Crew	HDDV	40	5	200	1	1.1975	0.1213	0.1013	0.0058	0.7588	0.1561	0.0006	0.0001	0.0001	0.0000	0.0004	0.0001							0.2	0.000008	0.000010
	Pickup Completion, Pusher	LDDT	40	5	200	1	1.0194	0.0479	0.0390	0.0025	2.7544	1.2112	0.0005	0.0000	0.0000	0.0000	0.0014	0.0006							0.1	0.000000	0.000012
	Pickup Perforators, Engineer	LDDT	40	2	80	1	0.4078	0.0192	0.0156	0.0010	1.1018	0.4845	0.0002	0.0000	0.0000	0.0000	0.0006	0.0002							0.0	0.000000	0.000005
	Pickup Fracing, Engineer	HDDV	40	1	40	1	0.2395	0.0243	0.0203	0.0012	0.1518	0.0312	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000							0.0	0.000002	0.000002
	Pickup Co. Supervisor	LDDT	40	10	400	1	2.0388	0.0959	0.0780	0.0049	5.5088	2.4224	0.0010	0.0000	0.0000	0.0000	0.0028	0.0012							0.2	0.000001	0.000023
	Pickup Miscellaneous Supplies	LDDT	40	3	120	1	0.6116	0.0288	0.0234	0.0015	1.6526	0.7267	0.0003	0.0000	0.0000	0.0000	0.0008	0.0004							0.1	0.000000	0.000007
	Pickup Roustabout Crew	HDDV	40	4	160	1	0.9580	0.0971	0.0810	0.0047	0.6071	0.1249	0.0005	0.0000	0.0000	0.0000	0.0003	0.0001							0.1	0.000007	0.000008
																		Subtotal	4.36E-02	3.72E-03	3.09E-03	1.81E-04	5.42E-02	1.93E-02	1.12E+01	4.30E-04	7.97E-04
																		Total	5.11E-02	4.44E-03	3.69E-03	2.15E-04	6.07E-02	2.11E-02	1.33E+01	5.22E-04	9.25E-04

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust and Fugitive Dust Emissions from Well Work Overs (Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads
Emission Factors for Industrial Unpaved Roads [a]

E (lb/VMT) =	$k (s/12)^a (W/3)^b$
E_{ext} = E (1 - P/365)	

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption:	Avg. Frequency & Duration: three days, once in the first year; Equipment: Truck-mounted Unit: capacity **600 hp**, fuel **60 gpd**, hours/day **10** Truck: Type **WO rig**, Round trip mileage: **10** miles on unpaved road Max. number of crews in the field on a given day considering weekends and inclement weather: **15**

Fugitive Dust Estimations for Road Traffic

Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	1.50	15.03	0.01	0.15	1.50	0.00
	Haul Truck	42	10	1	10	1	1.50	15.03	0.01	0.15	1.50	0.00
	Pickup Truck	5	10	3	30	1	0.58	17.30	0.01	0.06	1.73	0.00
								Total	**2.37E-02**			**2.37E-03**

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)								
	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Diesel	0.30	0.015	0.11	2.60	0.14	0.02	530.28	0.004	0.006

Sources: Tier 4 non-road diesel emission factors for non-SO2, non-GHG pollutants. EPA NONROADS 2008a (Year 2008) for CO2 and CH4.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Engines

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	Total # of Wells Drilled	Max. Annual Emissions													
							(lbs/well)					(tpy/well)								
							NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	12	1	5	103	6	**5.95E-03**	**2.98E-04**	**2.27E-03**	**5.16E-02**	**2.78E-03**	**2.98E-04**	**1.05E+01**	**7.56E-05**	**1.19E-04**

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}[a,b]	$PM_{2.5}$[a,b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions															
							(lbs/well)						(tpy/well)									
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.05	0.000	0.000
												Total	**5.45E-04**	**3.86E-05**	**3.20E-05**	**1.90E-06**	**9.78E-04**	**3.95E-04**	**1.24E-01**	**3.53E-06**	**1.09E-05**

Performed once in the first year of well operation

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust and Fugitive Dust Emissions from Well Work Overs (Non-Federal)

Fugitive Dust from Heavy Equipment on Industrial Unpaved Roads

Emission Factors for Industrial Unpaved Roads [a]

		Parameter	PM_{10}	$PM_{2.5}$
E (lb/VMT) =	$k (s/12)^a (W/3)^b$	k	1.5	0.15
		a	0.9	0.9
		b	0.45	0.45
E_{ext} = E (1 - P/365)				

Function/Variable Description	Assumed Value	Reference
E = size-specific emission factor (lb/VMT)		
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)		
s = surface material silt content (%)	34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
W = mean vehicle weight (tons)	Listed in the table below	
M = surface material moisture content (%)	2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year	96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of or scoria gravel surfacing	84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption:	Avg. Frequency & Duration: three days, once in the first year; Equipment: Truck-mounted Unit: capacity **600 hp**, fuel **60 gpd**, hours/day **10** Truck: Type **WO rig**, Round trip mileage: **10** miles on unpaved road Max. number of crews in the field on a given day considering weekends and inclement weather: **15**

Fugitive Dust Estimations for Road Traffic

Activity	Vehicle Type	Avg. Vehicle Weight (tons)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well)	$PM_{2.5}$ Emissions (tpy/well)
Well Workover	WO Rig	42	10	1	10	1	1.50	15.03	0.01	0.15	1.50	0.00
	Haul Truck	42	10	1	10	1	1.50	15.03	0.01	0.15	1.50	0.00
	Pickup Truck	5	10	3	30	1	0.58	17.30	0.01	0.06	1.73	0.00
								Total	**2.37E-02**			**2.37E-03**

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Exhaust Emissions from Well Work Overs

Emission Factors Bore/Drill Rig Engines 300-600 Hp

Fuel Type	Emission Factors (gm/hp-hr)								
	NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O [a]
Diesel	6.69	0.38	0.11	2.25	0.48	0.37	529.58	0.007	0.006

Source: EPA NONROADS 2008a. Year 2008.

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Engines

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	# of Operating Hours/Well	Total # of Wells Drilled	Max. Annual Emissions (lbs/well) NO_x	PM_{10}	SO_x	CO	VOC	Max. Annual Emissions (tpy/well) NO_x	PM_{10}	SO_x	CO	VOC	PM2.5	CO_2	CH_4	N_2O
Well Workover	Truck-Mounted Unit	600	10	3	30	1	266	15	5	89	19	**1.33E-01**	**7.55E-03**	**2.26E-03**	**4.46E-02**	**9.61E-03**	**7.32E-03**	**1.05E+01**	**1.46E-04**	**1.20E-04**

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust emission factors for commuting vehicles

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}[a,b]	$PM_{2.5}$[a,b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.044

Source: MOBILE 6.2.03

Emission factors for 2008 used for all project years = conservative estimate of vehicle fleet turnover

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Total # of Wells Drilled	Max. Annual Emissions															
							(lbs/well)						(tpy/well)									
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Workover	WO Rig	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Haul Truck	HDDV	40	1	40	1	0.240	0.024	0.020	0.001	0.152	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.03	0.000	0.000
	Pickup Truck	LDDT	40	3	120	1	0.612	0.029	0.023	0.001	1.653	0.727	0.000	0.000	0.000	0.000	0.001	0.000	0.05	0.000	0.000
												Total	**5.45E-04**	**3.86E-05**	**3.20E-05**	**1.90E-06**	**9.78E-04**	**3.95E-04**	**1.24E-01**	**3.53E-06**	**1.09E-05**

Performed once in the first year of well operation

Number of wells is based on peak year applied to all project years (provides for a conservative estimate).

Natural Gas Wells - Alternatives A, B, C, and D

Fugitive Dust and Exhaust Emissions from Site Visits and Inspections

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Assumption:
Frequency of visit: once/week/well
Crew: **1** person and **1** light-duty truck
Av. number of wells served by a pumper per day **20**
Round trip mileage per day: 50 total/20 wells = 2.**5** miles/well on unpaved road

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/well/ yr)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/ well/yr)	$PM_{2.5}$ Emissions (tpy/ well)
Inspection Visits for Wells	Pickup Truck	40	2.5	52	130	1	0.53	69.54	**3.48E-02**	0.05	6.95	**3.47E-03**

Exhaust Emissions from Site Visits and Inspections

Emission factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}[a, b]	$PM_{2.5}$[a, b]	SO_x[a]	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Gasoline Truck	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: MOBILE 6.2.03
Emission factors for 2008 used for all years = conservative estimate for fleet vehicle turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year	Miles Traveled/ Well/Year	Federal Wells Producing	Emissions														
							(lbs/well/yr)						(tpy/well)								
	Type	Class					NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Inspection Visits for Wells	Pickup Truck	LDGT2	2.5	52	130	1	0.32	0.01	0.00	0.00	6.87	0.31	**1.61E-04**	**3.63E-06**	**1.68E-06**	**1.26E-06**	**3.43E-03**	**1.53E-04**	**6.83E-02**	**9.74E-06**	**2.56E-05**

Natural Gas Wells - Alternatives A, B, C, and D

Exhaust Emissions from Heavy Equipment and Support Vehicles for Road Maintenance

Given Data

Maintenance[a]	Equipment/Vehicle			Road Length Worked on/Day (miles)	# of Operating Hours/Day
	Type	Fuel	Capacity (hp)		
Summer	Heavy Equipment[b]	Diesel-30 gpd	135	6	10
	Commuting Vehicle	Gas-5 gpd	225	6	1[c]
Winter	Heavy Equipment[b]	Diesel-30 gpd	135	5	10
	Commuting Vehicle	Gas-5 gpd	225	6	1.5[c]

[a] Road maintenance would be made twice in summer and once in winter every yea
[b] Assume a motor grader 135 Hp.
[c] Assume three round trips per two days.

Estimation of Total and Cumulative Length of Roads for the Project - RMP Year 20

Length of Improved Roads per Well (miles) [a]	1.00
Number of Wells	1.00
Cumulative Length of Roads [b] (miles/operation)	1.00

[a] Source: SEIS
[b] miles of road built per well * No. of operating wells/year

Estimation of Total Operation Days and Hours - RMP Year 20

Season	# of Operations per Season	Cumulative Length of Roads (miles/operation)	Road Length Worked On (mi/day)	# of Operating Hours per Day	Total # of Operating Days	Total # of Operating Hours
Summer	2	1	6	10	0.3	3
Winter	1	1	5	10	0.2	2
				Total	0.5	5

Emission Factors for Grading - Fugitive Dust

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Em. Factors (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^2$	5	0.765
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

[a] S = mean vehicle speed (S), assume 5 mph for grading
Source: EPA AP-42, Section 11.9, Table 11.9-1, Oct. 1998

Fugitive Dust Emission Estimations for Grader: RMP Year 20

Activity	Equipment	Total # of Operating Hours [a]	Mean Vehicle Speed (mph)	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
					Emissions (lb/year)	Emissions (tpy)	Emissions (lb/year)	Emissions (tpy)
Road Maintenance	Grader	3	5	16	12.24	**6.12E-03**	1.11	**5.55E-04**

[a] Assume grader operates at 60% of the time (minus hours for clothing change, breaks, etc.)

Emission Factors for Construction Equipment Exhaust

Equipment	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	PM2.5	CO_2	CH_4	N_2O[a]
Grader 100-175 Hp	4.34	0.34	0.12	1.51	0.35	0.33	535.77	0.0053	0.006

Source: EPA NONROADS 2008a
Use emission factors for 2008 for all project years - conservative estimate of vehicle turnover
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Natural Gas Wells - Alternatives A, B, C, and D

Emission Estimations for Grader: RMP Year 20

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours[a]	Emissions (lbs/activity/hr)					Emissions (tons/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Road Maintenance	Grader	135	3	1.29	0.10	0.04	0.45	0.10	2.07E-03	1.62E-04	5.71E-05	7.19E-04	1.67E-04	1.57E-04	2.55E-01	2.52E-06	2.88E-06

[a] Assume grader operates at 60% of the time (minus hours for clothing change, breaks, etc.)

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (\mathrm{lb/VMT}) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	PM_{10} Emission Factor (lb/VMT)	PM_{10} Emissions (lbs/yr)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Emission Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/yr)	$PM_{2.5}$ Emissions (tpy)
Road Maintenance	Pickup Truck	40	40	0.5	21	0.53	11.41	5.71E-03	0.05	1.14	5.70E-04

Emission Factors for Commuting Vehicles Exhaust

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE 6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Estimations for Road Traffic - RMP Year 20

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled (VMT/yr)	Emissions (tpy/well)								
						NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Maintenance	Pickup Truck	LDDT	40	0.5	21	5.44E-05	2.56E-06	2.08E-06	1.32E-07	1.47E-04	6.46E-05	9.63E-03	4.70E-08	1.25E-06

Natural Gas Wells - Alternatives A, B, C, and D

Emission Factors for Industrial Wind Erosion

E (tpy) = $k * \frac{P * M * N}{453.6 * 2000}$ — AP-42 Section 13.2.5.3 Equation 2

Erosion Potential P (g/m2/year) = $58(U^*-Ut^*)^2 + 25(U^*-Ut^*)$ — for U*>Ut*; P=0 otherwise — AP-42 Section 13.2.5.3 Equation 3

Friction Velocity U* (m/s) = $0.053\ U_{10}^*$ — AP-42 Section 13.2.5.3 Equation 4

P = Erosion Potential (gm/m^2/yr) — M = Disturbed area (m^2)
U* = Friction velocity (m/s) — N = # of disturbances
U_t = threshold velocity (m/s) — k = 0.5 for PM_{10}
U10 = fastest wind speed (m/s) — k = 0.075 for $PM_{2.5}$

U_{10} = 26.08 — 58.33 average fastest (mph) for Billings, Montana (1939-1987) from http://www.itl.nist.gov/div898/winds/nondirectional.htm
U_t well pads = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material
U_t roads/pipelines = 1.33 AP-42 Industrial Wind Erosion Table 13.2.5-2, Roadbed material

Construction Wind Erosion Emissions - Based on Peak Wells Drilled each Alternative

	Fastest Mile (U_{10}) (m/s)	Max. Friction Velocity (U*) (m/s)	Well Erosion Potential (P) (g/m^2/yr)	Road Erosion Potential (P) (g/m^2/yr)	Peak # of Wells Drilled per year	Average Disturbed acres per well [a]	Disturbed Area (M) (m^2)	Number of Disturbances (N)	PM10 Emissions (tpy/well)	PM2.5 Emissions (tpy/well)
Well pad construction	26.08	1.38	1.46		1.00	4.00	16193.31	1.00	0.01	0.00
Road and Pipeline Construction	26.08	1.38		1.46	1.00	1.50	6072.49	1.00	0.00	0.00
								TOTAL	**1.79E-02**	**2.68E-03**

[a] Average disturbed area shown in SEIS

Natural Gas Wells - Alternatives A, B, C, and D

Emissions for Road and Well Pad Reclamation

Type	Equipment/Vehicle			Total Miles Worked on/Day	# of Operating Hours/Day
	Type	Fuel	Capacity (hp)		
Roads	Heavy Equipment	Diesel	80	6	10
	Commuting Vehicle	Gasoline	225	6	1.5
Wells[a]	Heavy Equipment	Diesel	100	N/A	10
	Commuting Vehicle	Gasoline	225	6	2

[a] Assume 0.5 day with a blade and tractor each for reseeding per well at time of abandonment.
Source: values from SEIS

Estimation of Total Miles of Roads

Length of Roads Built per Well	0.25
Number of Roads Reclaimed Annually Per Well	1.060
Annual Miles of Roads Reclaimed Per Well	0.265
Number of wells reclaimed (per well)	1.060

Reclamation rates derived from RMP (total Federal and non-Federal)

Estimation of Total Operation Days and Hours

Annual Miles of Roads Reclaimed	Daily Miles of Road Work	Total # of Operating Days	Annual Operating Hours
0.2650	6	0.04417	0.4417
		Total	**0.442**

Assume average miles/day = 6

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)	S[a] (mph)	Emission Factor (lb/VMT)
PM_{10}	$E = (0.6)(0.051)\ S^2$	5	0.765
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$	5	0.069

[a] Assumed a mean vehicle speed (S) of 5 mph.
Source: EPA AP-42, Section 11.9, Table 11.9-1

Fugitive Dust Emissions Estimation for Grader - Road Reclamation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Maintained	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Road Reclamation	Grader	0.265	5	1.325	0.765	**5.07E-04**	0.069	**4.59E-05**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Emission Factors for 75-100 hp Off-Road Engines

Year	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[a]
2008	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.006
2018	2.40	0.41	0.11	2.33	0.36	0.40	613.9	0.006	0.006
2027	0.64	0.19	0.10	0.75	0.18	0.19	608.6	0.003	0.006

Source: EPA NONROADS 2008a
[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Grader Road Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Road Reclamation	Grader	80	0.265	0.4238	0.0720	0.0197	0.4106	0.0629	**5.62E-05**	**9.54E-06**	**2.61E-06**	**5.44E-05**	**8.33E-06**	**9.25E-06**	**1.43E-02**	**1.29E-07**	**1.41E-07**

Natural Gas Wells - Alternatives A, B, C, and D

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Emissions Estimation for Commuting Vehicles: Road Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10} Em. Factor (lb/VMT)[a]	PM_{10} (tpy/well)	$PM_{2.5}$ Em. Factor (lb/VMT)[a]	$PM_{2.5}$ (tpy/well)
Road Reclamation	Pickup Truck	40	60	0.0442	2.650	0.53	**7.09E-04**	0.05	**7.08E-05**

[a] No dust control measures would be applied.

Exhaust Emission Factors for Commuting Reclamation Vehicles Road Traffic

Vehicle Class	Emission Factors (g/mi)								
	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
Light-Duty Diesel Truck	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Commuting Reclamation Vehicles: Road Traffic

Activity	Vehicle Type	Vehicle Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Road Reclamation	Pickup Truck	LDDV	60	0.0442	2.6500	**6.75E-06**	**3.18E-07**	**2.59E-07**	**1.64E-08**	**1.82E-05**	**8.02E-06**	**1.20E-03**	**5.84E-09**	**1.55E-07**

Estimation of Annual Days and Hours for Well Reclamation

Equipment	# of Wells Reclaimed/Year	# of Hours/Day	Annual # of Days	Annual Hours of Operation
Grader	1.060	10	1.060	10.60

Assume grader works 0.5 day as a blade and tractor each per well.

Natural Gas Wells - Alternatives A, B, C, and D

Fugitive Dust Emissions Estimation for Grader: Well Reclamation

Activity	Equipment	Total # of Operating Hours[a]	Mean Vehicle Speed (mph)	Total Miles Reclaimed	PM_{10}		$PM_{2.5}$	
					Em. Factor (lb/VMT)	(tpy/well)	Em. Factor (lb/VMT)	(tpy/well)
Well Reclamation	Grader	6.36	5	31.80	0.765	**1.22E-02**	0.069	**1.10E-03**

[a] Assumed a grader operates 60% of the time, considering hours for preparation and closing of the shift, lunch break, and other extra activities.

Exhaust Emissions Estimation for Grader: Well Reclamation

Activity	Vehicle Type	Capacity (hp)	Total # of Operating Hours	Emissions													
				(lbs/hour)					(tpy/well)								
				NO_x	PM_{10}	SO_x	CO	VOC	NO_x	PM_{10}	SO_x	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Well Reclamation	Grader	100	6.36	0.5297	0.0900	0.0246	0.5132	0.0786	**1.68E-03**	**2.86E-04**	**7.82E-05**	**1.63E-03**	**2.50E-04**	**4.44E-04**	**4.21E-01**	**7.01E-06**	**4.24E-06**

Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle Type	Class	Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	PM_{10}		$PM_{2.5}$	
						Em. Factor (lb/VMT)[a]	(tpy/well)	Em. Factor (lb/VMT)[a]	(tpy/well)
Well Reclamation	Pickup Truck	LDDV	60	1.06	63.60	0.535	**1.70E-02**	0.053	**1.70E-03**

[a] No dust control measures would be applied.

Exhaust Emissions Estimation for Commuting Vehicles: Well Reclamation

Activity	Vehicle		Round Trip Distance (miles/day)	Total # of Operating Days	Total Miles Traveled	Emissions (tpy/well)								
	Type	Class				NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Well Reclamation	Pickup Truck	LDDV	60	1.06	63.60	**1.62E-04**	**7.62E-06**	**6.20E-06**	**3.93E-07**	**4.38E-04**	**1.93E-04**	**2.87E-02**	**1.40E-07**	**3.72E-06**

Natural Gas Wells - Alternatives A, B, C, and D

Emission Factors for Dehydrator Heaters

Unit	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
lb/MMSCF	100	7.60	0.60	84	5.50	5.7	120000	2.3	0.075	2.2
lb/MMBTU	0.098	0.007	0.001	0.082	0.005	0.006	117.647	0.002	0.000	0.002

Source: EPA, AP-42 Section 1.4 Natural Gas Combustion

Emission Estimate for Dehydrator Heaters

Operating Hours per Year[a]	Dehydrator Heater Size MMBtu/Hour	Fuel Usage MMCF/Year	Number of Dehydrator Stations / Well	Emissions (tpy/well)									
				NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
2,190	1	2.20	0.001	**1.26E-04**	**9.56E-06**	**7.55E-07**	**1.06E-04**	**6.92E-06**	**7.17E-06**	**1.51E-01**	**2.89E-06**	**9.43E-08**	**2.77E-06**

Values from Montana BLM (Laakso, 2010)

Annual Dehydrator Venting and Tank Flashing Emissions

Annual Well Gas Production MMscf	CH_4 Emission Factor (ton per MMscf)	CH_4 Emissions (TPY/well)	VOC Emission Factor (ton per MMscf)	VOC Emissions (TPY/well)	HAPs Emission Factor (ton per MMscf)	HAPs Emissions (TPY/well)
14.60	0.016	**2.27E-01**	0.00002	**3.11E-04**	0.00001	**1.51E-04**

Gas analysis and dehydration process information provided by Montana BLM (Laakso, 2010) and emissions estimated with GLYCalc Program.
Emission factor include emissions from dehy/regenerator still vents (no control) and flash tank emissions (no control).
Assumed 100% of gas production flows through dehydrators at sales compressor station (Laakso, 2010)

The following Compressor Station assumptions were used with natural gas Well specific gas composition analysis to derive dehydrator emissions:
per dehydrator:

wet gas temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
wet gas pressure:		450	psi	Laakso, 2010 - South Baker Compressor Station
gas is saturated	---	---		Laakso, 2010 - South Baker Compressor Station
dry gas flow rate:		35	MMCFD	Laakso, 2010 - South Baker Compressor Station
dry gas water content:		3.2	lbs/MMscf	Laakso, 2010 - South Baker Compressor Station
lean glycol water content:		0.2	wt%	Laakso, 2010 - South Baker Compressor Station
lean glycol circulation rate:		5	gpm	Laakso, 2010 - South Baker Compressor Station
flash tank temperature:		108	degrees F	Laakso, 2010 - South Baker Compressor Station
flash tank pressure:		60	psi	Laakso, 2010 - South Baker Compressor Station
stripping gas source:	dry gas	---		Laakso, 2010 - South Baker Compressor Station
stripping gas flow rate:		17	scfm	Laakso, 2010 - South Baker Compressor Station

Natural Gas Wells - Alternatives A, B, C, and D

Wellhead Fugitives
Fugitive Emissions from Equipment Leaks

TOC Emission Factor								
Well Equipment Component	Gas		Light Oil >20º API		Heavy Oil <20º API		Water/Oil	
	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)
valves	4.50E-03	9.92E-03	2.50E-03	5.51E-03	8.40E-06	1.85E-05	9.80E-05	2.16E-04
pump seals	2.40E-03	5.29E-03	1.30E-02	2.87E-02	3.20E-05	7.05E-05	2.40E-05	5.29E-05
others	8.80E-03	1.94E-02	7.50E-03	1.65E-02	3.20E-05	7.05E-05	1.40E-02	3.09E-02
connectors	2.00E-04	4.41E-04	2.10E-04	4.63E-04	7.50E-06	1.65E-05	1.10E-04	2.43E-04
flanges	3.90E-04	8.60E-04	1.10E-04	2.43E-04	3.90E-07	8.60E-07	2.90E-06	6.39E-06
open-ended lines	2.00E-03	4.41E-03	1.40E-03	3.09E-03	1.40E-04	3.09E-04	2.50E-04	5.51E-04

Source: EPA-453/R-95-017 Protocol for Equipment Leak Emission Estimates, November 1995
Table 2-4 , Oil and Gas Production Operations Average Estimation Factors
"Other" category includes compressor seals, pressure relief valves, diaphragms, drains, dump arms, hatches, instruments, meters, polished rods and vents

From Montana BLM provided NG analysis

VOC Wt% =	0.68
CO2 Wt% =	0.30
CH4 Wt% =	89.00
N2O Wt% =	0.00

Emissions from Equipment Leaks at Wellhead per Well

component	Ave. # in Gas Service	Emission factor (lb/hr)	Ave. # in Liquid service	Emission factor (lb/hr)	Ave. # in Water/Oil Service	Emission factor (lb/hr)	TOC emissions per well (lb/hr)	VOC emissions per well (lb/hr)	CO_2 emissions per well (lb/hr)	CH_4 emissions per well (lb/hr)
valves	7	0.0099	1	0.0055	0	0.0002	0.07496	0.00051	0.00022	0.06671
pump seals	0	0.0053	0	0.0287	0	0.0001	0.00000	0.00000	0.00000	0.00000
others	0	0.0194	0	0.0165	0	0.0309	0.00000	0.00000	0.00000	0.00000
connectors	24	0.0004	0	0.0005	0	0.0002	0.01058	0.00007	0.00003	0.00942
flanges	2	0.0009	0	0.0002	0	0.0000	0.00172	0.00001	0.00001	0.00153
open-ended lines	0	0.0044	0	0.0031	0	0.0006	0.00000	0.00000	0.00000	0.00000
TOTAL emissions/well/hr =							0.08726	0.00060	0.00026	0.07766

Number of components provided by Montana BLM FO personnel (Laakso, 2010)

Annual Emissions from Equipment Leaks Per Well								
Year	**Number of Producing Wells**	**Operating Hours**	**VOC emissions (lb/yr)**	**VOC emissions (tpy)**	**CO_2 emissions (lb/yr)**	**CO2 emissions (tpy)**	**CH_4 emissions (lb/yr)**	**CH4 emissions (tpy)**
RMP Year	1	8760	5.22	**2.61E-03**	2.29	**1.14E-03**	680.28	**3.40E-01**

Natural Gas Wells - Alternatives A, B, C, and D

Speciated Analysis - NG & Venting Emissions from Well Completion Activities (applied to all wells drilled)

Gas Component	Mole Fraction	Molecular Weight	Gas Weight	Weight Percent	Weight	Emissions Mass Flow
	(%)	(lb/lb-mol)	(lb/lb-mol)	(wt%)	(lb/MMscf))	(ton/well)
Methane	93.716	16.040	15.032	88.998	37788.643	2.267319
Ethane	1.624	30.070	0.488	2.891	1227.616	0.073657
Nitrogen	4.297	28.020	1.204	7.128	3026.751	0.181605
Water	0.000	18.015	0.000	0.000	0.000	0.000000
Carbon Dioxide	0.115	43.990	0.051	0.300	127.173	0.007630
Nitrous Oxide	0.000	44.020	0.000	0.000	0.000	0.000000
Hydrogen Sulfide	0.000	34.060	0.000	0.000	0.000	0.000000
Non-reactive, non-HAP	99.752	---	16.775	99.317		2.530211
Propane	0.211	44.100	0.093	0.551	233.918	0.014035
Iso-butane	0.019	58.120	0.011	0.065	27.760	0.001666
n-butane	0.015	58.120	0.009	0.052	21.916	0.001315
i-pentane	0.002	72.150	0.001	0.009	3.628	0.000218
n-pentane	0.001	72.150	0.001	0.004	1.814	0.000109
Hexanes	0.000	100.210	0.000	0.000	0.000	0.000000
Heptanes	0.000	100.200	0.000	0.002	0.781	0.000047
Octanes	0.000	114.230	0.000	0.000	0.000	0.000000
Nonanes	0.000	128.258	0.000	0.000	0.000	0.000000
Decanes+	0.000	142.29	0.000	0.000	0.000	0.000000
Reactive VOC	0.248	---	0.115	0.683		0.017389
Benzene	0.000	78.110	0.000	0.000	0.000	0.000000
Ethylbenzene	0.000	106.160	0.000	0.000	0.000	0.000000
n-Hexane [3]	*0.000*	*100.210*	*0.000*	*0.000*	*0.000*	*0.000000*
Toluene	0.000	92.130	0.000	0.000	0.000	0.000000
Xylenes	0.000	106.160	0.000	0.000	0.000	0.000000
HAPs	0.000	---	0.000	0.000		0.000000
Totals	**100.000**	**---**	**16.890**	**100.000**		**2.547600**

Sample taken 03-09-2010 at Baker South 7 W 0429.

Volume Flow:	40 MSCF/day/well
Completion activity duration:	3 days
Total Volume Flow per Well	0.12 MMSCF/well

Assume: Gas density is 0.04246 lb/scf (19.26 g/scf).

BTU value = 994 BTU/scf

Natural Gas Wells - Alternatives A, B, C, and D

Compressor Station Emissions
Emission Factors for Natural Gas-Fired Compressors

Compressor		Horse-Power Rating	Units	Emission Factors									
				NO_x[a]	PM_{10}[b]	SO_2[b]	CO[a]	VOC[a]	$PM_{2.5}$[b]	CO_2[c]	CH_4[c]	HCHO[b]	N_2O[c]
Field Compression Station	Rich Burn	300	gm/bhp-hr	1.00	0.044	0.001	2.00	0.70	0.044	134.9	2.5E-03	0.064	2.55E-04
			lb/MMBTU		3.84E-02	5.88E-04			3.84E-02	116.9	2.2E-03	5.52E-02	2.20E-04
Sales Compression Station	Rich Burn	1,680	gm/bhp-hr	1.00	0.044	0.001	2.00	0.70	0.044	134.9	0.003	0.064	2.55E-04
			lb/MMBTU		3.84E-02	5.88E-04			3.84E-02	116.9	2.20E-03	5.52E-02	2.20E-04

[a] Source: assume compressors will comply with NSPS 40 CFR part 60 subpart JJJJ
[b] Source: EPA, AP-42 Section 3.2 Natural Gas Fired Reciprocating Engines
Note: Compressors assumed to be equipped with nonselective catalytic reduction (NSCR) catalyst.
[c] EPA Mandatory GHG Reporting, Part 98, Subpart C, Tables C-1 and C-2.

Emission Estimations for Compressors

Type of Compressors	Compression Rate (Hp/well)	Annual # of Wells in Production	Total Compression (Hp)	Operating Hours/Year	Emissions (tpy/well)									
					NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	HCHO	N_2O
Field Compression Station	11	1	11	8,760	0.11	0.00	0.00	0.21	0.07	0.00	14.427	0.0003	0.01	0.00003
Sales Compression Station	10	1	10	8,760	0.10	0.00	0.00	0.20	0.07	0.00	13.465	0.0003	0.01	0.00003
				Total	**2.07E-01**	**9.16E-03**	**1.40E-04**	**4.13E-01**	**1.45E-01**	**9.16E-03**	**2.79E+01**	**5.26E-04**	**1.32E-02**	**5.26E-05**

HCHO = Formaldehyde

Compression rate of 36 - 300 hp field compressors, and 6 - 1680 hp sales compressors per 867 CBNG wells based on BLM survey (Laakso, 2010). Values were scaled based on per well NG production.

Compressor Station Fugitives
Fugitive Emissions from Equipment Leaks

Well Equipment Component	TOC Emission Factor							
	Gas		Light Oil >20° API		Heavy Oil <20° API		Water/Oil	
	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)	(kg/hr)	(lb/hr)
valves	4.50E-03	9.92E-03	2.50E-03	5.51E-03	8.40E-06	1.85E-05	9.80E-05	2.16E-04
pump seals	2.40E-03	5.29E-03	1.30E-02	2.87E-02	3.20E-05	7.05E-05	2.40E-05	5.29E-05
others	8.80E-03	1.94E-02	7.50E-03	1.65E-02	3.20E-05	7.05E-05	1.40E-02	3.09E-02
connectors	2.00E-04	4.41E-04	2.10E-04	4.63E-04	7.50E-06	1.65E-05	1.10E-04	2.43E-04
flanges	3.90E-04	8.60E-04	1.10E-04	2.43E-04	3.90E-07	8.60E-07	2.90E-06	6.39E-06
open-ended lines	2.00E-03	4.41E-03	1.40E-03	3.09E-03	1.40E-04	3.09E-04	2.50E-04	5.51E-04

Source: EPA-453/R-95-017 Protocol for Equipment Leak Emission Estimates, November 1995
Table 2-4 , Oil and Gas Production Operations Average Estimation Factors
"Other" category includes compressor seals, pressure relief valves, diaphragms, drains, dump arms, hatches, instruments, meters, polished rods and vents

From Montana BLM provided NG analysis

VOC Wt% =	0.68
CO2 Wt% =	0.30
CH4 Wt% =	89.00
N2O Wt% =	0.00

Natural Gas Wells - Alternatives A, B, C, and D

Emissions from Equipment Leaks at Compressor Station per Well

component	Ave. # in Gas Service / Well	Emission factor (lb/hr)	Ave. # in Liquid service	Emission factor (lb/hr)	Ave. # in Water/Oil Service	Emission factor (lb/hr)	TOC emissions per well (lb/hr)	VOC emissions per well (lb/hr)	CO_2 emissions per well (lb/hr)	CH_4 emissions per well (lb/hr)
valves	0.258	0.0099	0	0.0055	0	0.0002	0.003	0.000	0.000	0.002
pump seals	0.000	0.0053	0	0.0287	0	0.0001	0.000	0.000	0.000	0.000
others	0.000	0.0194	0	0.0165	0	0.0309	0.000	0.000	0.000	0.000
connectors	0.369	0.0004	0	0.0005	0	0.0002	0.000	0.000	0.000	0.000
flanges	0.886	0.0009	0	0.0002	0	0.0000	0.001	0.000	0.000	0.001
open-ended lines	0.000	0.0044	0	0.0031	0	0.0006	0.000	0.000	0.000	0.000
						TOTAL emissions/well/hr =	0.00349	0.00002	0.00001	0.00310

Number of components provided by Montana BLM FO personnel (Laakso, 2010)

Annual Emissions from Equipment Leaks Per Well									
Year	**Number of Producing Wells**	**Operating Hours**	**VOC (lb/yr)**	**VOC (tpy)**	**CO_2 (lb/yr)**	**CO_2 (tpy)**	**CH_4 (lb/yr)**	**CH4 (tpy)**
RMP Year	1	8760	0.21	**1.04E-04**	0.0915	**4.58E-05**	27.1891	**1.36E-02**

Natural Gas Wells - Alternatives A, B, C, and D

***Emission Factors for Publicly Accessible Unpaved Roads*[a]**

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control efficiency of gravel or scoria surfacing		84%	WRAP Fugitive Dust Handbook, September 2006.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Road Traffic

Activity	Compressor Station	Vehicle Type	Avg. Vehicle Speed (mph)	# of Compressor Stations / Well	# of Inspection Visits/ Station/ Year	# of Inspection Visits/Well/Year	Total Miles/ Inspection	PM_{10} Em. Factor (lb/VMT)	PM_{10} Emissions (lbs/trip)	PM_{10} Emissions (tpy/well)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (lbs/trip)	$PM_{2.5}$ Emissions (tpy/well)
Inspection Visits for Compressor Stations	Field Station	Pickup Truck	40	0.04	12	0.4	20	0.53	10.70	0.00	0.05	1.07	0.00
	Sales Station	Pickup Truck	40	0.01	52	0.3	20	0.53	10.70	0.00	0.05	1.07	0.00
									Total	4.08E-03			4.08E-04

Assume no dust control (watering)

Compressor Station Inspection Traffic Exhaust Emissions
Emission factors for Commuting Vehicles Exhaust

Vehicle Type	Vehicle Class	NO_x	PM_{10}	$PM_{2.5}$	SOx	CO	VOC	CO_2	CH_4	N_2O[a]
		Emission Factors (g/mi)								
Light-Duty Diesel Truck	LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053

Source: MOBILE6.2.03

[a] N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Exhaust Emissions Estimation for Road Traffic

Activity	Compressor Station	Vehicle Type	Vehicle Class	# of Compressor Stations / Well	# of Inspection Visits/ Station	# of Inspection Visits/Well/Year	Total Miles/ Inspection	Emissions (lbs/trip) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	Emissions (tpy/well) NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O
Inspection Visits for Compressor Stations	CPF Compressor Station	Pickup Truck	LDDT	0.04	12	0.4	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00	0.00400	0.00000	0.00000
	Primary Compressor Station	Pickup Truck	LDDT	0.01	52	0.3	20	0.102	0.005	0.004	0.000	0.275	0.121	0.00	0.00	0.00	0.00	0.00	0.00	0.00289	0.00000	0.00000
													Total	3.89E-05	1.83E-06	1.49E-06	9.42E-08	1.05E-04	4.62E-05	6.89E-03	3.36E-08	8.91E-07

General Purpose BLM Fleet Travel - Alternatives A, B, C, and D

General Purpose Travel - BLM Fleet **Alternatives A-D**

Total Annual Emissions from General Purpose BLM Travel - Alternatives A-D

	Annual Emissions (Tons)											
Activity	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Commuting Vehicles - Fugitive Dust	54.91	5.49	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.02	0.02	0.48	0.00	1.31	0.57	0.06	85.55	0.00	0.01	88.99	80.76
Total	**54.94**	**5.51**	**0.48**	**0.00**	**1.31**	**0.57**	**0.06**	**85.55**	**0.00**	**0.01**	**88.99**	**80.76**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

General Purpose BLM Fleet Travel - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved roads [b]		0%	No control is assumed.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Fleet Group	Avg. Vehicle Speed (mph)	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/fleet group)	PM_{10} Emissions (tpy)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/fleet group)	$PM_{2.5}$ Emissions (tpy)
General Purpose BLM Travel	All Vehicles	25	41,555	2.64	54.91	54.91	0.26	5.49	5.49
		Total	**41,555**	**Total**	**54.91**			**5.487**	

Source of activity data: Billings Field Office (Craig Drake 9/12/2011 spreadsheet).
Assumes no surfacing or water application to control dust from unpaved roads.

General Purpose BLM Fleet Travel - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Fleet Group[a]	Class	Total Annual Vehicle Miles Traveled	Emissions (tons/yr)								
				NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
General Purpose BLM Travel	All Fleets	LDDT	189,531	0.48	0.02	0.02	0.00	1.31	0.57	85.55	0.00	0.01
			Total	**0.4830**	**0.0227**	**0.0185**	**0.00117**	**1.31**	**0.57390**	**8.56E+01**	**4.18E-04**	**1.11E-02**

Source of activity data: Billings Field Office (Craig Drake 9/12/2011 spreadsheet).

[a] All vehicles are considered diesel-powered.

BLM Road Maintenance - Alternatives A, B, C, and D

BLM Road Maintenance **Alternatives A-D**

Total Annual Emissions from Road Maintenance Projects - Alternatives A-D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Road Maintenance	1.65	0.19	0.53	0.01	0.20	0.04	0.00	60.42	0.00	0.00	60.64	55.03
Total	**1.65**	**0.19**	**0.53**	**0.01**	**0.20**	**0.04**	**0.00**	**60.42**	**0.0006**	**0.0007**	**60.64**	**55.03**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

BLM Road Maintenance - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D
Road Maintenance - Independent of Well Road Maintenance

Annual Average Miles of Maintained Road

Cumulative Length of Maintained Roads (miles)	115

Emission Factors for Grader

Pollutant	Emission Factor Equation (lb/VMT)[a]
PM_{10}	$E = (0.6)(0.051)\ S^2$
$PM_{2.5}$	$E = (0.031)(0.04)\ S^{2.5}$

[a] Mean vehicle speed (S)
Source: EPA AP-42, Section 11.9, Table 11.9-1

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Source of activity data: Craig Drake of Billings Field Office, 9-19-2011.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		80	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control percent		0%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*
[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.
* no emissions controls

Estimation of Annual Fugitive Dust Emissions - All Project Years

Activity	Equipment	Total # of Operating Hours	Mean Vehicle Speed (mph)	Total Miles Traveled/ Year	PM_{10} Em. Factor (lb/VMT)	PM_{10} Emissions (tons/year)	$PM_{2.5}$ Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/year)
Road Maintenance	Grader	150	5	750	0.765	0.29	0.069	0.03
Road Maintenance	Semi-truck	100	20	200	2.51	0.25	0.25	0.03
Road Maintenance	Lowboy Trailer	100	20	756	2.51	0.95	0.25	0.09
				Total	**1.49**		**0.15**	

BLM Road Maintenance - Alternatives A, B, C, and D

Emission Factors for Off-Road Engines

Horsepower	Emission Factors (g/hp-hr)								
	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
100 - 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
~ 300	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.
Source of activity data: MCFO

Combustive Emissions for Grader - Road Maintenance

Equipment	Horsepower	# of Units	Av. Load Factor (%)	Hours/Year	Emissions (tons/year)								
					NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forklift	100	0	0.10	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Backhoe	87	0	0.80	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Semi-truck	450	1	0.50	100	0.11	0.01	0.00	0.04	0.01	0.01	13.29	0.00	0.00
Lowboy Trailer	450	1	0.50	100	0.11	0.01	0.00	0.04	0.01	0.01	13.29	0.00	0.00
Bobcat	82	1	0.80	500	0.18	0.01	0.00	0.07	0.02	0.01	19.52	0.00	0.00
Grader	165	1	0.90	150	0.12	0.01	0.00	0.05	0.01	0.01	13.26	0.00	0.00
Loader	60	1	0.75	40	0.01	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00
Dump Truck	350	0	0.50	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Airport Forklift	100	0	0.10	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Snowplow	350	0	0.25	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				Total	**5.3E-01**	**3.6E-02**	**1.3E-02**	**2.0E-01**	**3.9E-02**	**3.5E-02**	**6.0E+01**	**5.9E-04**	**6.8E-04**

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	258.0	34.6	30	121.812	0.033	1,047.58	0	**0.13**	**0.01**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* assume roadway 12 feet wide for disturbance estimation.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation (not used)
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30% derived from Billings, Montana Airport surface meteorology 1980-1989 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Coal Mining - Alternatives A, B, C, and D

BiFO Coal Mining Emission Estimates

Mine	Emissions (tpy)						
	CO [1]	NO_x [1]	VOC [1]	SO_2 [1]	PM10 [2]	PM2.5 [2]	CO_2 [3]
Signal Peak Energy LLC (Bull Mountains Mine No. 1)	11.3	23.7	1.2	0.0	29.9	3.0	274.4

1. Non-particulate criteria air pollutants are based on emissions reported in the 2008 NEI.

2. PM10 emissions are based on Montana Department of Environmental Quality Permit Number #3179-04 (February 5, 2009) for the facility. PM2.5 emissions are assumed to be equal to 10 percent of PM10 emissions.

3. CO2 emissions are estimated from fuel use based on information in the Bull Mountains Mine No. 1 Environmental Assessment (DOI-BLM-MT-C010-2009-0010-EA, April, 2011) and information from the air quality permit. See calculations below for GHG emissions.

Non-Boiler Liquid Fuel Combustion GHG Emissions

Fuel Type	Annual Usage (gal/yr)	Emissions (lb/gal)			Emissions (tpy)		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Gaoline	11,000	19.4	Negl.	Negl.	106.7	Negl.	Negl.
Diesel	181,000	22.2	Negl.	Negl.	122.1	Negl.	Negl.

CO2 emission factors are based on IPCC recommended calculation procedures summarized in "Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel", http://www.epa.gov/oms/climate/420f05001.htm, accessed 8/31.2011.

Boiler GHG Emissions

Fuel Type	Annual Usage		Heating Value [2]		CO_2 Emission Factors		CO_2 Emissions
	Quantity	Usage Units	High Heat Value	High Heat Value Units	(kg CO_2/ MMBtu) [2]	(ton CO_2/ MMBtu)	(tpy)
Sub-bituminous coal [1]	26	short ton/yr	17.25	MMBtu/short ton	97.02	0.05	21.8
Propane	8517	gal/yr	0.09	MMBtu/gal	61.46	0.03	23.8

[1] The air quality permit allows combustoin of up to 26 tons per year of coal in facility boilers, which include two 35,000 Btu/hr boilers. Propane is used for remaining fuel. Based on 80% boiler efficiency, total fuel needed is estimated to be 767 MMBtu/yr. Based on maximum allowable coal combustion, propane usage would be 8,517 gal/yr.

[2] Source: 40 CFR Part 98, Subpart C. Table C-1.

Fire Management Resource - Alternative A

Fire Management and Ecology **Alternative A**

Total Annual Emissions from Fire Management Projects - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	258.88	222.33	72.09	19.76	2,581.48	131.66	13.17	0.00	136.73	19.81	9,012.40	8,178.22
Heavy Equipment Exhaust	0.18	0.23	7.43	0.65	9.55	1.58	0.16	309,157.85	34.39	11.52	313,452.58	284,439.72
Commuting Vehicles - Fugitive Dust	8.76	0.88	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.10	0.00	0.11	0.06	0.01	28.91	0.00	0.00	29.45	26.72
Total	**267.8**	**223.4**	**79.6**	**20.4**	**2,591.1**	**133.3**	**13.3**	**309,186.8**	**171.1**	**31.3**	**322,494.4**	**292,644.7**
Emissions Without Wildfire Smoke	**55.7**	**38.0**	**19.4**	**3.9**	**433.2**	**23.2**	**13.3**	**309,072.5**	**154.6**	**31.3**	**322,494.4**	**292,644.7**
% of Emissions From Wildfire Smoke	**79%**	**83%**	**76%**	**81%**	**83%**	**83%**	**0%**	**0%**	**10%**	**0%**	**0%**	**0%**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Fire Management Resource - Alternative A

ALTERNATIVE: Alternative A

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	c	Percentage of TSP
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	d	Percentage of PM_{10}

[a] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.
[b] EPA, AP-42, Volume I, Section 13.2.3 Heavy Construction Operations, Jan. 1995 (Errata Feb. 2010)
[c] EPA, AP-42, Volume I, Section 13.2.4 Aggregate Handling and Storage Piles, Nov. 2006
[d] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10}[c]	$PM_{2.5}$[c]
Mechanical Treatments (Hand Work)	157	1	0.20	0.02
Prescribed Fire	471	1	0.61	0.06
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	0	1	0.00	0.00
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**3.94**	**0.39**

[a] Source: BiFO
[b] Assume land area disturbed once, therefore input one day to complete for calculation purposes.
[c] Assume only 25% of treated acreage is disturbed by heavy equipment

	Emission Factor[a] (tons/acre burned)								
Activity	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**SO_2**	**CO**	**VOC**	**CO_2[b]**	**CH_4**	**N_2O**
Prescribed and Wild Fire	0.088	0.077	0.025	0.007	0.899	0.046		0.048	0.0069

[a] Derived from From: Western Governor's Association/Western Regional Air Partnership 2002 Fire Emission Inventory For the WRAP Region - Phase II July 22, 2005
[b] No emission factor for CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from Fire - All Project Years

Area of Activity & Type of Treatment	Annual Acreage	PM_{10} (tons/year)	$PM_{2.5}$ (tons/year)	NO_x (tons/year)	SO_2 (tons/year)	CO (tons/year)	VOC (tons/year)	CO_2 (tons/year)	CH_4 (tons/year)	N_2O[a] (tons/year)
Prescribed Fire	471	41.64	36.39	11.83	3.24	423.50	21.60	0.00	22.43	3.2499
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**253.81**	**221.82**	**72.09**	**19.76**	**2581.48**	**131.66**	**0.00**	**136.73**	**19.81**

[a] Based on average fuel loading for Region 2: Rocky Mountain = 30 tons/acre from AP-42 Table 13.1-1

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	3,028	34.6	30	89.673	0.033	9,051.03	0	**1.13**	**0.11**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2006)

Fire Management Resource - Alternative A

ALTERNATIVE: Alternative A

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100 Hp	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Additional Equipment

	Emission Factors gm/LTO								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft Landing/Take-Off Cycle (LTO)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

Source: IPCC Guidelines on National Greenhouse Gas Inventories. Reference Manual, page 1.98, Table 2, Domestic Average Fleet and Cruise. Jet fuel A density ~ 8lbs/gallon.

Combustive Emission Estimations for Fire Management Activities

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hrs/ Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions													
									(lbs/year)					(tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Mechanical Treatments	Skid Steer Loader	75	1	50	6	40	1	240	93.31	10.66	2.54	76.98	9.14	0.05	0.01	0.00	0.04	0.00	0.01	5.90	0.00	0.00
	Chain Saw	5.4	4	80	6	40	1	960	12.10	89.13	1.28	2,683.75	565.84	0.01	0.04	0.00	1.34	0.28	0.05	2.72	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	15	1	75	14.58	1.67	0.40	12.03	1.43	0.01	0.00	0.00	0.01	0.00	0.00	0.92	0.00	0.00
	Chain Saw	5.4	2	40	5	15	1	150	0.94	6.96	0.10	209.67	44.21	0.00	0.00	0.00	0.10	0.02	0.01	0.21	0.00	0.00
	Pumps	25	2	95	5	15	1	150	10.39	76.56	1.10	2,305.38	486.06	0.01	0.04	0.00	1.15	0.24	0.00	2.34	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.00	1.18	0.00	0.00
	Chain Saw	5.4	20	50	6	20	1	2400	18.90	139.26	2.00	4,193.36	884.12	0.01	0.07	0.00	2.10	0.44	0.13	4.25	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Underground Coal Seam Fire	Excavator	100	1	80	8	5	1	40	33.18	3.79	0.90	27.37	3.25	0.02	0.00	0.00	0.01	0.00	0.00	2.10	0.00	0.00
	Water Tender	75	1	50	8	5	1	40	15.55	1.78	0.42	12.83	1.52	0.01	0.00	0.00	0.01	0.00	0.00	0.98	0.00	0.00
													Total	**0.26**	**0.18**	**0.01**	**4.89**	**1.01**	**0.23**	**39.28**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative).

Combustive Emission Estimations for Fire Management Activities - Additional Equipment

Activity	Equipment Type	# of LTO/year	gallons of fuel used/trip (cruising)	trips/year	gallons (cruising)/ year	Emissions													
						(lbs/year)					(tons/year)								
						NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Prescribed Fire	Aircraft	2	76	2	152	59.72	0.00	4.87	45.10	12.40	0.03	0.00	0.00	0.02	0.01	0.00	11,818.69	1.32	0.44
Wild Fire	Aircraft	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
					Total	14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

Activity data source: BiFO, weighted average of Field personnel data survey response.

Fire Management Resource - Alternative A

ALTERNATIVE: Alternative A
Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^{a}\,(S/30)^{d}}{(M/0.5)^{c}} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*
[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Mechanical Treatments (Hand Work)	Support Truck	35	30	40	1,200	1	1200	1.56	0.94	1.17	0.16	0.09	0.12
	ATV	20	20	20	400	1	400	1.18	0.24		0.12	0.02	
Prescribed Fires	Fire Truck	30	70	15	1,050	1	1050	1.45	0.76	3.29	0.14	0.08	0.33
	Fuel Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Water Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Support Truck	35	70	15	1,050	1	1050	1.56	0.82		0.16	0.08	
	UTV/ATV	20	40	8	320	1	320	1.18	0.19		0.12	0.02	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	**8.76**			**0.88**	

Source of activity data: BiFO. Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: MOBILE6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)								
Type	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips per Project	Vehicle Miles Traveled /Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Year	Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Mechanical Treatments (Hand Work)	Support Truck	HDDV	150	40	6,000	1	6,000	0.02	0.00	0.00	0.00	0.01	0.00	5.24	0.00	0.00
	ATV	R12S	20	20	400	1	400	0.00	0.00	0.00	0.00	0.02	0.02	0.06	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Fuel Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Water Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Support Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	UTV / ATV	R12S	40	8	320	1	320	0.00	0.00	0.00	0.00	0.02	0.02	0.05	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	Fuel Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	Water Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	Support Truck	HDDV	190	20	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	3.32	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.10**	**0.01**	**0.01**	**0.00**	**0.11**	**0.06**	**28.91**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative). Activities were estimated based on an annual, rather than a project, basis.

Fire Management Resource - Alternative B

Fire Management and Ecology **Alternative B**

Total Annual Emissions from Fire Management Projects - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	372.72	313.01	101.19	27.74	3,623.60	184.80	18.48	0.00	191.93	27.81	12,650.64	11,479.71
Heavy Equipment Exhaust	0.20	0.18	7.46	0.65	9.84	1.64	0.16	309,161.89	34.39	11.52	313,456.62	284,443.40
Commuting Vehicles - Fugitive Dust	11.98	1.20	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.10	0.00	0.14	0.09	0.01	29.22	0.00	0.00	29.76	27.01
Total	**384.9**	**314.4**	**108.8**	**28.4**	**3,633.6**	**186.5**	**18.7**	**309,191.1**	**226.3**	**39.3**	**326,137.0**	**295,950.1**
Emissions Without Wildfire Smoke	**172.7**	**129.0**	**48.5**	**11.9**	**1,475.6**	**76.5**	**18.7**	**309,076.8**	**209.8**	**39.3**	**326,137.0**	**295,950.1**
% of Emissions From Wildfire Smoke	**55%**	**59%**	**55%**	**58%**	**59%**	**59%**	**0%**	**0%**	**7%**	**0%**	**0%**	**0%**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Fire Management and Ecology **Alternative B Compared to Alternative A**

Total Annual Emissions from Fire Management Projects - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	$CO2_{eq}$	CO_{2eq} metric Tonnes
Increase From Alternative A	**68%**	**71%**	**60%**	**67%**	**71%**	**70%**	**29%**	**0%**	**26%**	**20%**	**1%**	**1%**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Fire Management Resource - Alternative B

ALTERNATIVE: Alternative B

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	c	Percentage of TSP
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	d	Percentage of PM_{10}

[a] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.
[b] EPA, AP-42, Volume I, Section 13.2.3 Heavy Construction Operations, Jan. 1995 (Errata Feb. 2010)
[c] EPA, AP-42, Volume I, Section 13.2.4 Aggregate Handling and Storage Piles, Nov. 2006
[d] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10}[c]	$PM_{2.5}$[c]
Mechanical Treatments (Hand Work)	540	1	0.70	0.07
Prescribed Fire	1,630	1	2.12	0.21
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	5,254	1	6.83	0.68
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**12.77**	**1.28**

[a] Source: BiFO
[b] Assume land area disturbed once, therefore input one day to complete for calculation purposes.
[c] Assume only 25% of treated acreage is disturbed by heavy equipment

Activity	Emission Factor[a] (tons/acre burned)								
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	CO_2[b]	CH_4	N_2O
Prescribed and Wild Fire	0.088	0.077	0.025	0.007	0.899	0.046		0.048	0.0069

[a] Derived from From: Western Governor's Association/Western Regional Air Partnership 2002 Fire Emission Inventory For the WRAP Region - Phase II July 22, 2005
[b] No emission factor for CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from Fire - All Project Years

Area of Activity & Type of Treatment	Annual Acreage	PM_{10} (tons/year)	$PM_{2.5}$ (tons/year)	NO_x (tons/year)	SO_2 (tons/year)	CO (tons/year)	VOC (tons/year)	CO_2 (tons/year)	CH_4 (tons/year)	N_2O [a] (tons/year)
Prescribed Fire	1630	144.10	125.94	40.93	11.22	1465.62	74.75	0.00	77.63	11.247
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**356.27**	**311.37**	**101.19**	**27.74**	**3623.60**	**184.80**	**0.00**	**191.93**	**27.81**

[a] Based on average fuel loading for Region 2: Rocky Mountain = 30 tons/acre from AP-42 Table 13.1-1

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	9,824	34.6	30	89.673	0.033	29,365.04	0	**3.67**	**0.37**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2006)

Fire Management Resource - Alternative B

ALTERNATIVE: Alternative B

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100 Hp	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Additional Equipment

	Emission Factors gm/LTO								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft Landing/Take-Off Cycle (LTO)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

Source: IPCC Guidelines on National Greenhouse Gas Inventories. Reference Manual, page 1.98, Table 2, Domestic Average Fleet and Cruise. Jet fuel A density ~ 8lbs/gallon.

Combustive Emission Estimations for Fire Management Activities

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hrs/ Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Mechanical Treatments	Skid Steer Loader	75	1	50	6	75	1	450	174.96	20.00	4.76	144.34	17.14	0.09	0.01	0.00	0.07	0.01	0.02	11.06	0.00	0.00
	Chain Saw	5.4	4	80	6	75	1	1800	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.10	5.10	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	25	1	125	24.30	2.78	0.66	20.05	2.38	0.01	0.00	0.00	0.01	0.00	0.01	1.54	0.00	0.00
	Chain Saw	5.4	2	40	5	25	1	250	1.57	11.60	0.17	349.45	73.68	0.00	0.01	0.00	0.17	0.04	0.01	0.35	0.00	0.00
	Pumps	25	2	95	5	25	1	250	17.32	127.60	1.84	3,842.30	810.10	0.01	0.06	0.00	1.92	0.41	0.00	3.89	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.00	1.18	0.00	0.00
	Chain Saw	5.4	2	60	6	20	1	240	2.27	16.71	0.24	503.20	106.09	0.00	0.01	0.00	0.25	0.05	0.01	0.51	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Resource Benefit	Chain Saw	5.4	2	25	6	20	1	240	0.94	6.96	0.10	209.67	44.21	0.00	0.00	0.00	0.10	0.02	0.00	0.21	0.00	0.00
	Pumps	25	2	15	8	20	1	320	12.44	1.42	0.34	10.26	1.22	0.01	0.00	0.00	0.01	0.00	0.00	0.79	0.00	0.00
													Total	**0.29**	**0.20**	**0.01**	**5.19**	**1.07**	**0.18**	**43.32**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative).

Combustive Emission Estimations for Fire Management Activities - Additional Equipment

Activity	Equipment Type	# of LTO/year	gallons of fuel used/trip (cruising)	trips/year	gallons (cruising)/ year	Emissions (lbs/year)					Emissions (tons/year)								
						NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Prescribed Fire	Aircraft	2	76	2	152	59.72	0.00	4.87	45.10	12.40	0.03	0.00	0.00	0.02	0.01	0.00	11,818.69	1.32	0.44
Wild Fire	Aircraft	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
Total						14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

Activity data source: BiFO, weighted average of Field personnel data survey response.

Fire Management Resource - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Mechanical Treatments (Hand Work)	Support Truck	35	30	75	2,250	1	2250	1.56	1.76	2.21	0.16	0.18	0.22
	ATV	20	20	38	760	1	760	1.18	0.45		0.12	0.04	
Prescribed Fires	Fire Truck	30	70	25	1,750	1	1750	1.45	1.27	5.48	0.14	0.13	0.55
	Fuel Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Water Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Support Truck	35	70	25	1,750	1	1750	1.56	1.37		0.16	0.14	
	UTV/ATV	20	40	13	520	1	520	1.18	0.31		0.12	0.03	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	**11.98**			**1.20**	

Source of activity data: BiFO. Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: MOBILE6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)								
Type	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips per Project	Vehicle Miles Traveled /Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Year	Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Mechanical Treatments (Hand Work)	Support Truck	HDDV	150	75	11,250	1	11,250	0.03	0.00	0.00	0.00	0.02	0.00	9.82	0.00	0.00
	ATV	R12S	20	38	760	1	760	0.00	0.00	0.00	0.00	0.04	0.04	0.12	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Fuel Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Water Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Support Truck	HDDV	190	25	1750	1	1,750	0.01	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00
	UTV / ATV	R12S	40	13	520	1	520	0.00	0.00	0.00	0.00	0.03	0.03	0.08	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Fuel Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Water Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Support Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.10**	**0.01**	**0.01**	**0.00**	**0.14**	**0.09**	**29.22**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative). Activities were estimated based on an annual, rather than a project, basis.

Fire Management Resource: Alternative C

Fire Management and Ecology **Alternative C**

Total Annual Emissions from Fire Management Projects - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	363.92	312.13	101.19	27.74	3,623.60	184.80	18.48	0.00	191.93	27.81	12,650.64	11,479.71
Heavy Equipment Exhaust	0.27	0.07	7.46	0.66	12.00	2.10	0.21	309,165.48	34.39	11.52	313,460.22	284,446.67
Commuting Vehicles - Fugitive Dust	11.98	1.20	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.10	0.00	0.14	0.09	0.01	29.22	0.00	0.00	29.76	27.01
Total	**376.2**	**313.4**	**108.8**	**28.4**	**3,635.7**	**187.0**	**18.7**	**309,194.7**	**226.3**	**39.3**	**326,140.6**	**295,953.4**
Emissions Without Wildfire Smoke	**164.0**	**128.0**	**48.5**	**11.9**	**1,477.8**	**76.9**	**18.7**	**309,080.4**	**209.8**	**39.3**	**326,140.6**	**295,953.4**
% of Emissions From Wildfire Smoke	**56%**	**59%**	**55%**	**58%**	**59%**	**59%**	**0%**	**0%**	**7%**	**0%**	**0%**	**0%**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

ALTERNATIVE: Alternative C

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS

Description	Value	Source	Notes
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	c	Percentage of TSP
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	d	Percentage of PM_{10}

[a] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.
[b] EPA, AP-42, Volume I, Section 13.2.3 Heavy Construction Operations, Jan. 1995 (Errata Feb. 2010)
[c] EPA, AP-42, Volume I, Section 13.2.4 Aggregate Handling and Storage Piles, Nov. 2006
[d] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year)	
			PM_{10}[c]	$PM_{2.5}$[c]
Mechanical Treatments (Hand Work)	540	1	0.70	0.07
Prescribed Fire	1,630	1	2.12	0.21
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	0	1	0.00	0.00
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**5.94**	**0.59**

[a] Source: BiFO
[b] Assume land area disturbed once, therefore input one day to complete for calculation purposes.
[c] Assume only 25% of treated acreage is disturbed by heavy equipment

Activity	Emission Factor[a] (tons/acre burned)								
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	CO_2[b]	CH_4	N_2O
Prescribed and Wild Fire	0.088	0.077	0.025	0.007	0.899	0.046		0.048	0.0069

[a] Derived from From: Western Governor's Association/Western Regional Air Partnership 2002 Fire Emission Inventory For the WRAP Region - Phase II July 22, 2005
[b] No emission factor for CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from Fire - All Project Years

Area of Activity & Type of Treatment	Annual Acreage	PM_{10} (tons/year)	$PM_{2.5}$ (tons/year)	NO_x (tons/year)	SO_2 (tons/year)	CO (tons/year)	VOC (tons/year)	CO_2 (tons/year)	CH_4 (tons/year)	N_2O[a] (tons/year)
Prescribed Fire	1630	144.10	125.94	40.93	11.22	1465.62	74.75	0.00	77.63	11.247
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**356.27**	**311.37**	**101.19**	**27.74**	**3623.60**	**184.80**	**0.00**	**191.93**	**27.81**

[a] Based on average fuel loading for Region 2: Rocky Mountain = 30 tons/acre from AP-42 Table 13.1-1

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	4,570	34.6	30	89.673	0.033	13,660.25	0	**1.71**	**0.17**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2006)

Fire Management Resource: Alternative C

ALTERNATIVE: Alternative C

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr) NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Logging Equipment

Year 2008	Emission Factors (g/hp-hr) NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100 Hp	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Additional Equipment

	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Emission Factors gm/LTO									
Aircraft Landing/Take-Off Cycle (LTO)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
Emission Factors gm/gallon fuel									
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

Source: IPCC Guidelines on National Greenhouse Gas Inventories. Reference Manual, page 1.98, Table 2, Domestic Average Fleet and Cruise. Jet fuel A density ~ 8lbs/gallon.

Combustive Emission Estimations for Fire Management Activities

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hrs/ Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year) NO_x	PM_{10}	SO_2	CO	VOC	Emissions (tons/year) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Mechanical Treatments	Skid Steer Loader	75	1	50	6	75	1	450	174.96	20.00	4.76	144.34	17.14	0.09	0.01	0.00	0.07	0.01	0.02	11.06	0.00	0.00
	Chain Saw	5.4	4	80	6	75	1	1800	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.01	5.10	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	25	1	125	24.30	2.78	0.66	20.05	2.38	0.01	0.00	0.00	0.01	0.00	0.01	1.54	0.00	0.00
	Chain Saw	5.4	2	40	5	25	1	250	1.57	11.60	0.17	349.45	73.68	0.00	0.01	0.00	0.17	0.04	0.00	0.35	0.00	0.00
	Pumps	25	2	95	5	25	1	250	17.32	127.60	1.84	3,842.30	810.10	0.01	0.06	0.00	1.92	0.41	0.00	3.89	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.01	1.18	0.00	0.00
	Chain Saw	5.4	20	60	6	20	1	2400	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.01	5.10	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Resource Benefit	Chain Saw	5.4	2	25	6	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pump	25	2	15	8	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
													Total	**0.29**	**0.27**	**0.01**	**7.34**	**1.53**	**0.07**	**46.91**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative).

Combustive Emission Estimations for Fire Management Activities - Additional Equipment

Activity	Equipment Type	# of LTO/year	gallons of fuel used/trip (cruising)	trips/year	gallons (cruising)/ year	Emissions (lbs/year) NO_x	PM_{10}	SO_2	CO	VOC	Emissions (tons/year) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Prescribed Fire	Aircraft	2	76	2	152	59.72	0.00	4.87	45.10	12.40	0.03	0.00	0.00	0.02	0.01	0.00	11,818.69	1.32	0.44
Wild Fire	Aircraft	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
Total						14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

Activity data source: BiFO, weighted average of Field personnel data survey response.

Fire Management Resource: Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Mechanical Treatments (Hand Work)	Support Truck	35	30	75	2,250	1	2250	1.56	1.76	2.21	0.16	0.18	0.22
	ATV	20	20	38	760	1	760	1.18	0.45		0.12	0.04	
Prescribed Fires	Fire Truck	30	70	25	1,750	1	1750	1.45	1.27	5.48	0.14	0.13	0.55
	Fuel Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Water Truck	30	70	25	1,750	1	1750	1.45	1.27		0.14	0.13	
	Support Truck	35	70	25	1,750	1	1750	1.56	1.37		0.16	0.14	
	UTV/ATV	20	40	13	520	1	520	1.18	0.31		0.12	0.03	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	**11.98**			**1.20**	

Source of activity data: BIFO. Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: MOBILE6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)								
Type	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips per Project	Vehicle Miles Traveled /Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Year	Emissions (tons/year) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Mechanical Treatments (Hand Work)	Support Truck	HDDV	150	75	11,250	1	11,250	0.03	0.00	0.00	0.00	0.02	0.00	9.82	0.00	0.00
	ATV	R12S	20	38	760	1	760	0.00	0.00	0.00	0.00	0.04	0.04	0.12	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Fuel Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Water Truck	HDDV	190	25	4,750	1	4,750	0.01	0.00	0.00	0.00	0.01	0.00	4.15	0.00	0.00
	Support Truck	HDDV	190	25	1750	1	1,750	0.01	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00
	UTV / ATV	R12S	40	13	520	1	520	0.00	0.00	0.00	0.00	0.03	0.03	0.08	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Fuel Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Water Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Support Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.10**	**0.01**	**0.01**	**0.00**	**0.14**	**0.09**	**29.22**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative). Activities were estimated based on an annual, rather than a project, basis.

Fire Management Resource - Alternative D

Fire Management and Ecology **Alternative D**

Total Annual Emissions from Fire Management Projects - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	$CO2_{eq}$	CO_{2eq} metric Tonnes
Fugitive Dust and Smoke	374.45	313.19	101.19	27.74	3,623.60	184.80	18.48	0.00	191.93	27.81	12,650.64	11,479.71
Heavy Equipment Exhaust	0.19	0.23	7.41	0.65	9.95	1.67	0.17	309,155.62	34.39	11.52	313,450.34	284,437.69
Commuting Vehicles - Fugitive Dust	8.76	0.88	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.06	0.00	0.08	0.05	0.01	18.96	0.00	0.00	19.32	17.53
Total	**383.4**	**314.3**	**108.7**	**28.4**	**3,633.6**	**186.5**	**18.7**	**309,174.6**	**226.3**	**39.3**	**326,120.3**	**295,934.9**
Emissions Without Wildfire Smoke	**171.2**	**128.9**	**48.4**	**11.9**	**1,475.7**	**76.5**	**18.7**	**309,060.3**	**209.8**	**39.3**	**326,120.3**	**295,934.9**
% of Emissions From Wildfire Smoke	**55%**	**59%**	**55%**	**58%**	**59%**	**59%**	**0%**	**0%**	**7%**	**0%**	**0%**	**0%**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS

Description	Value	Source	Notes
Control Efficiency (C) of watering	0.5	a	
TSP Emission Factor	1.2	b	Tons TSP/acre-month
Conversion factor for TSP to PM_{10}	0.26	c	Percentage of TSP
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	d	Percentage of PM_{10}

[a] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions* , EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.
[b] EPA, AP-42, Volume I, Section 13.2.3 Heavy Construction Operations, Jan. 1995 (Errata Feb. 2010)
[c] EPA, AP-42, Volume I, Section 13.2.4 Aggregate Handling and Storage Piles, Nov. 2006
[d] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Fire Management - Mechanical Treatment (Hand Work) and Prescribed Fire

Area of Activity & Type of Treatment	Average Annual Disturbed Acreage	# of Days to Complete/Year[b]	Emissions (tons/year) PM_{10}[c]	Emissions (tons/year) $PM_{2.5}$[c]
Mechanical Treatments (Hand Work)	540	1	0.70	0.07
Prescribed Fire	1,630	1	2.12	0.21
Wild Fire	2,400	1	3.12	0.31
Resource Benefit	6,293	1	8.18	0.82
Coal Seam Fire	Negl.	1	0.00	0.00
		Total	**14.12**	**1.41**

[a] Source: BiFO
[b] Assume land area disturbed once, therefore input one day to complete for calculation purposes.
[c] Assume only 25% of treated acreage is disturbed by heavy equipment

Activity	Emission Factor[a] (tons/acre burned) PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	CO_2[b]	CH_4	N_2O
Prescribed and Wild Fire	0.088	0.077	0.025	0.007	0.899	0.046		0.048	0.0069

[a] Derived from From: Western Governor's Association/Western Regional Air Partnership 2002 Fire Emission Inventory For the WRAP Region - Phase II July 22, 2005
[b] No emission factor for CO_2 as emissions from fire are considered part of the carbon cycle

Smoke Emissions from Fire - All Project Years

Area of Activity & Type of Treatment	Annual Acreage	PM_{10} (tons/year)	$PM_{2.5}$ (tons/year)	NO_x (tons/year)	SO_2 (tons/year)	CO (tons/year)	VOC (tons/year)	CO_2 (tons/year)	CH_4 (tons/year)	N_2O[a] (tons/year)
Prescribed Fire	1630	144.10	125.94	40.93	11.22	1465.62	74.75	0.00	77.63	11.247
Wild Fire	2400	212.17	185.43	60.26	16.52	2157.97	110.06	0.00	114.30	16.56
	Total	**356.27**	**311.37**	**101.19**	**27.74**	**3623.60**	**184.80**	**0.00**	**191.93**	**27.81**

[a] Based on average fuel loading for Region 2: Rocky Mountain = 30 tons/acre from AP-42 Table 13.1-1

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	10,863	34.6	30	89.673	0.033	32,470.73	0	**4.06**	**0.41**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed roadways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = $1.7 \times (s/1.5) \times ([365-p]/235) \times (f/15)$, where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2006)

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr)								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100 Hp	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061

Source: EPA NONROADS 2008a
1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr

Emission Factors for Additional Equipment

	Emission Factors gm/LTO								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft Landing/Take-Off Cycle (LTO)	10200.00	0.00	800.00	8100.00	2600.00	0.00	2680000.00	300.00	100.00
	Emission Factors gm/gallon fuel								
	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Aircraft (cruise)	44.00	0.00	4.00	28.00	2.80	0.00	12600.00	0.00	0.40

Source: IPCC Guidelines on National Greenhouse Gas Inventories. Reference Manual, page 1.98, Table 2, Domestic Average Fleet and Cruise. Jet fuel A density ~ 8lbs/gallon.

Combustive Emission Estimations for Fire Management Activities

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hrs/ Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year)					Emissions (tons/year)								
									NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Mechanical Treatments	Skid Steer Loader	75	1	50	6	40	1	240	93.31	10.66	2.54	76.98	9.14	0.05	0.01	0.00	0.04	0.00	0.01	5.90	0.00	0.00
	Chain Saw	5.4	4	80	6	40	1	960	12.10	89.13	1.28	2,683.75	565.84	0.01	0.04	0.00	1.34	0.28	0.05	2.72	0.00	0.00
Prescribed Fire	Skid Steer Loader	75	1	25	5	15	1	75	14.58	1.67	0.40	12.03	1.43	0.01	0.00	0.00	0.01	0.00	0.00	0.92	0.00	0.00
	Chain Saw	5.4	2	40	5	15	1	150	0.94	6.96	0.10	209.67	44.21	0.00	0.00	0.00	0.10	0.02	0.01	0.21	0.00	0.00
	Pumps	25	2	95	5	15	1	150	10.39	76.56	1.10	2,305.38	486.06	0.01	0.04	0.00	1.15	0.24	0.00	2.34	0.00	0.00
Wild Fire	Dozer	100	1	15	6	20	1	120	18.66	2.13	0.51	15.40	1.83	0.01	0.00	0.00	0.01	0.00	0.00	1.18	0.00	0.00
	Chain Saw	5.4	20	60	6	20	1	2400	22.68	167.11	2.40	5,032.03	1,060.94	0.01	0.08	0.00	2.52	0.53	0.13	5.10	0.00	0.00
	Pumps	25	6	95	10	20	1	1200	295.50	33.77	8.04	243.77	28.94	0.15	0.02	0.00	0.12	0.01	0.02	18.68	0.00	0.00
Resource Benefit	Chain Saw	5.4	2	25	6	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pumps	25	2	15	8	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
													Total	**0.23**	**0.19**	**0.01**	**5.29**	**1.10**	**0.23**	**37.05**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative).

Combustive Emission Estimations for Fire Management Activities - Additional Equipment

Activity	Equipment Type	# of LTO/year	gallons of fuel used/trip (cruising)	trips/year	gallons (cruising)/ year	Emissions (lbs/year)					Emissions (tons/year)								
						NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Prescribed Fire	Aircraft	2	76	2	152	59.72	0.00	4.87	45.10	12.40	0.03	0.00	0.00	0.02	0.01	0.00	11,818.69	1.32	0.44
Wild Fire	Aircraft	50	2715	50	135750	14,292.33	0.00	1,285.27	9,272.49	1,124.56	7.15	0.00	0.64	4.64	0.56	0.00	297,299.88	33.07	11.08
					Total	14,352.05	0.00	1,290.14	9,317.58	1,136.96	**7.18**	**0.00**	**0.65**	**4.66**	**0.57**	**0.00**	**309,118.57**	**34.39**	**11.52**

Activity data source: BiFO, weighted average of Field personnel data survey response.

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D
Emission Factors for Road Traffic

$$E\ (lb/VMT) = \frac{k\ (s/12)^{a}\ (S/30)^{d}}{(M/0.5)^{c}} - C$$

$$E_{ext} = E\ (1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)		Listed in the table below	
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads [b]		50%	Source: Billings Field Office.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*
[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Mechanical Treatments (Hand Work)	Support Truck	35	30	40	1,200	1	1200	1.56	0.94	1.17	0.16	0.09	0.12
	ATV	20	20	20	400	1	400	1.18	0.24		0.12	0.02	
Prescribed Fires	Fire Truck	30	70	15	1,050	1	1050	1.45	0.76	3.29	0.14	0.08	0.33
	Fuel Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Water Truck	30	70	15	1,050	1	1050	1.45	0.76		0.14	0.08	
	Support Truck	35	70	15	1,050	1	1050	1.56	0.82		0.16	0.08	
	UTV/ATV	20	40	8	320	1	320	1.18	0.19		0.12	0.02	
Wild Fires	Fire Truck	30	70	20	1,400	1	1400	1.45	1.01	4.19	0.14	0.10	0.42
	Fuel Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Water Truck	30	70	20	1,400	1	1400	1.45	1.01		0.14	0.10	
	Support Truck	35	70	20	1,400	1	1400	1.56	1.09		0.16	0.11	
	UTV/ATV	20	20	5	100	1	100	1.18	0.06		0.12	0.01	
Coal Seam Fires	Support Truck	30	70	2	140	1	140	1.45	0.10	0.10	0.14	0.01	0.01
								Total	8.76			0.88	

Source of activity data: BIFO. Activities were determined on an annual rather than a project basis.

Fire Management Resource - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: MOBILE6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)								
Type	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips per Project	Vehicle Miles Traveled /Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Year	Emissions (tons/year) NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Mechanical Treatments (Hand Work)	Support Truck	HDDV	150	40	6,000	1	6,000	0.02	0.00	0.00	0.00	0.01	0.00	5.24	0.00	0.00
	ATV	R12S	20	20	400	1	400	0.00	0.00	0.00	0.00	0.02	0.02	0.06	0.00	0.00
Prescribed Fires	Fire Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Fuel Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Water Truck	HDDV	190	15	2,850	1	2,850	0.01	0.00	0.00	0.00	0.01	0.00	2.49	0.00	0.00
	Support Truck	HDDV	190	15	1050	1	1,050	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.00
	UTV / ATV	R12S	40	8	320	1	320	0.00	0.00	0.00	0.00	0.02	0.02	0.05	0.00	0.00
Wild Fires	Fire Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Fuel Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Water Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	Support Truck	HDDV	190	20	1400	1	1,400	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00
	UTV / ATV	R12S	20	5	100	1	100	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Coal Seam Fires	Support Truck	HDDV	190	2	380	1	380	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00
							Total	**0.06**	**0.01**	**0.01**	**0.00**	**0.08**	**0.05**	**18.96**	**0.00**	**0.00**

Activity data source: BiFO. Year 2008 emissions factors used (conservative). Activities were estimated based on an annual, rather than a project, basis.

Forestry and Woodland Products - Alternative A

Forest Products **Alternative A**

Total Annual Emissions from Forest and Woodlands Projects - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	1.86	0.19	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.06	0.06	0.74	0.02	0.52	0.08	0.01	86.70	0.00	0.00	87.01	78.96
Sub-total: Heavy Equipment	**1.92**	**0.24**	**0.74**	**0.02**	**0.52**	**0.08**	**0.01**	**86.70**	**0.00**	**0.00**	**87.01**	**78.96**
Commuting Vehicles - Fugitive Dust	0.95	0.10	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.03	0.00	0.03	0.01	0.00	7.37	0.00	0.00	7.53	6.83
Sub-total: Commuting Vehicles	**0.95**	**0.10**	**0.03**	**0.00**	**0.03**	**0.01**	**0.00**	**7.37**	**0.00**	**0.00**	**7.53**	**6.83**
Total	**2.87**	**0.34**	**0.76**	**0.02**	**0.55**	**0.09**	**0.01**	**94.07**	**0.001**	**0.001**	**94.54**	**85.79**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative A

ALTERNATIVE: Alternative A

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS

Description	Value	Source	Notes
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.
[b] WRAP Fugitive Dust Handbook, September 2006.
Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year) PM_{10}	Emissions (tons/year) $PM_{2.5}$
Forest/Woodland Forest Products		42	840	12	1.85	0.18
				Total	**1.85**	**0.18**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	42.0	34.6	30	96.3	89.673	0.033	125.54	0	**0.02**	**0.00**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Forestry and Woodland Products - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Skidder	205	1	70	8	12	96	142.83	16.32	3.89	117.83	13.99	7.1E-02	8.2E-03	1.9E-03	5.9E-02	7.0E-03	7.9E-03	9.0E+00	1.1E-04	9.2E-05
	Log Truck	450	1	60	10	12	120	335.93	17.59	8.24	125.81	15.95	1.7E-01	8.8E-03	4.1E-03	6.3E-02	8.0E-03	8.5E-03	1.9E+01	1.2E-04	2.2E-04
	Chainsaw	6	1	80	8	12	96	4.78	9.90	0.14	298.19	62.87	2.4E-03	5.0E-03	7.1E-05	1.5E-01	3.1E-02	4.6E-03	3.5E-01	2.7E-04	2.2E-06
	Feller Buncher	300	1	100	8	12	96	298.61	34.13	8.12	246.33	29.25	1.5E-01	1.7E-02	4.1E-03	1.2E-01	1.5E-02	1.7E-02	1.9E+01	2.2E-04	1.9E-04
	Loader	200	1	80	10	12	120	199.07	10.42	4.88	74.55	9.45	1.0E-01	5.2E-03	2.4E-03	3.7E-02	4.7E-03	5.1E-03	1.1E+01	7.2E-05	1.3E-04
	Dozer	200	1	90	8	12	96	179.16	9.38	4.39	67.10	8.51	9.0E-02	4.7E-03	2.2E-03	3.4E-02	4.3E-03	4.5E-03	1.0E+01	6.5E-05	1.2E-04
	Delimber	250	1	100	10	12	120	311.05	16.28	7.63	116.49	14.77	1.6E-01	8.1E-03	3.8E-03	5.8E-02	7.4E-03	7.9E-03	1.8E+01	1.1E-04	2.0E-04
												Total	**7.4E-01**	**5.7E-02**	**1.9E-02**	**5.2E-01**	**7.7E-02**	**5.5E-02**	**8.7E+01**	**9.7E-04**	**9.5E-04**

Source of activity data: Billings Field Office.

Assume 2008 emission factors for all years; this is a conservative estimate.

Forestry and Woodland Products - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved ro		50%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	30	12	360	1	360	1.32	0.24	0.95	0.13	0.02	0.10
	Log Truck	25	30	24	720	1	720	1.32	0.48		0.13	0.05	
	Pick-up Truck	25	30	12	360	1	360	1.32	0.24		0.13	0.02	
								Total	**0.95**			**0.10**	

Source of activity data: Billings Field Office.
Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions (tons/vehicle type)						Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	12	2,400	1	2,400	0.01	0.00	0.00	0.00	0.00	0.00							2.09	0.00	0.00
	Log Truck	HDDV	200	24	4,800	1	4,800	0.01	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.00	0.00	0.03	0.01	4.19	0.00	0.00
	Pick-up Truck	LDDT	200	12	2,400	1	2,400	0.01	0.00	0.00	0.00	0.02	0.01							1.08	0.00	0.00
							Total	**0.03**	**0.00**	**0.00**	**0.00**	**0.03**	**0.01**	**0.03**	**0.00**	**0.00**	**0.00**	**0.03**	**0.01**	**7.37**	**0.0003**	**0.0005**

Source of activity data: Billings Field Office.

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Forestry and Woodland Products - Alternative B

Forest Products **Alternative B**

Total Annual Emissions from Forest and Woodlands Projects - Alternative B

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	4.69	0.47	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.09	0.09	1.11	0.03	0.83	0.12	0.01	137.27	0.00	0.00	137.77	125.02
Sub-total: Heavy Equipment	**4.78**	**0.56**	**1.11**	**0.03**	**0.83**	**0.12**	**0.01**	**137.27**	**0.00**	**0.00**	**137.77**	**125.02**
Commuting Vehicles - Fugitive Dust	1.51	0.15	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.04	0.00	0.05	0.02	0.00	11.67	0.00	0.00	11.92	10.81
Sub-total: Commuting Vehicles	**1.51**	**0.15**	**0.04**	**0.00**	**0.05**	**0.02**	**0.00**	**11.67**	**0.00**	**0.00**	**11.92**	**10.81**
Total	**6.29**	**0.71**	**1.15**	**0.03**	**0.88**	**0.14**	**0.01**	**148.94**	**0.002**	**0.002**	**149.69**	**135.83**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative B

ALTERNATIVE: Alternative B
Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS

Description	Value	Source	Notes
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.
[b] WRAP Fugitive Dust Handbook, September 2006.
Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year) PM_{10}	Emissions (tons/year) $PM_{2.5}$
Forest/Woodland Forest Products		67	1,340	19	4.67	0.47
				Total	**4.67**	**0.47**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	67.0	34.6	30	96.3	89.673	0.033	200.27	0	**0.03**	**0.00**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Forestry and Woodland Products - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Skidder	205	1	70	8	19	152	226.15	25.85	6.15	186.56	22.15	1.1E-01	1.3E-02	3.1E-03	9.3E-02	1.1E-02	1.3E-02	1.4E+01	1.7E-04	1.5E-04
	Log Truck	450	1	60	10	19	190	496.50	27.84	13.04	199.20	25.26	2.5E-01	1.4E-02	6.5E-03	1.0E-01	1.3E-02	1.4E-02	3.0E+01	1.9E-04	3.4E-04
	Chainsaw	6	1	80	8	19	152	2.13	15.68	0.23	472.14	99.55	1.1E-03	7.8E-03	1.1E-04	2.4E-01	5.0E-02	7.2E-03	5.5E-01	4.3E-04	3.5E-06
	Feller Buncher	300	1	100	8	19	152	472.79	54.04	12.86	390.03	46.31	2.4E-01	2.7E-02	6.4E-03	2.0E-01	2.3E-02	2.6E-02	3.0E+01	3.5E-04	3.0E-04
	Loader	200	1	80	10	19	190	294.23	16.50	7.73	118.04	14.97	1.5E-01	8.2E-03	3.9E-03	5.9E-02	7.5E-03	8.0E-03	1.8E+01	1.1E-04	2.0E-04
	Dozer	200	1	90	8	19	152	264.80	14.85	6.96	106.24	13.47	1.3E-01	7.4E-03	3.5E-03	5.3E-02	6.7E-03	7.2E-03	1.6E+01	1.0E-04	1.8E-04
	Delimber	250	1	100	10	19	190	459.73	25.78	12.08	184.44	23.39	2.3E-01	1.3E-02	6.0E-03	9.2E-02	1.2E-02	1.3E-02	2.8E+01	1.8E-04	3.2E-04
												Total	**1.1E+00**	**9.0E-02**	**3.0E-02**	**8.3E-01**	**1.2E-01**	**8.7E-02**	**1.4E+02**	**1.5E-03**	**1.5E-03**

Source of activity data: Billings Field Office.

Assume 2008 emission factors for all years; this is a conservative estimate.

Forestry and Woodland Products - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved ro		50%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	30	19	570	1	570	1.32	0.38	1.51	0.13	0.04	0.15
	Log Truck	25	30	38	1,140	1	1,140	1.32	0.75		0.13	0.08	
	Pick-up Truck	25	30	19	570	1	570	1.32	0.38		0.13	0.04	
							Total		**1.51**			**0.15**	

Source of activity data: Billings Field Office.
Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	19	3,800	1	3,800	0.01	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.00	0.05	0.02	3.32	0.00	0.00
	Log Truck	HDDV	200	38	7,600	1	7,600	0.02	0.00	0.00	0.00	0.01	0.00							6.63	0.00	0.00
	Pick-up Truck	LDDT	200	19	3,800	1	3,800	0.01	0.00	0.00	0.00	0.03	0.01							1.72	0.00	0.00
							Total	**0.04**	**0.00**	**0.00**	**0.00**	**0.05**	**0.02**	**0.04**	**0.00**	**0.00**	**0.00**	**0.05**	**0.02**	**11.67**	**0.0005**	**0.0008**

Source of activity data: Billings Field Office.

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Forestry and Woodland Products - Alternative C

Forest Products **Alternative C**

Total Annual Emissions from Forest and Woodlands Projects - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	12.77	1.28	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.15	0.14	1.81	0.05	1.35	0.20	0.02	223.97	0.00	0.00	224.78	203.98
Sub-total: Heavy Equipment	**12.92**	**1.42**	**1.81**	**0.05**	**1.35**	**0.20**	**0.02**	**223.97**	**0.00**	**0.00**	**224.78**	**203.98**
Commuting Vehicles - Fugitive Dust	2.46	0.25	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.01	0.07	0.00	0.08	0.03	0.00	19.03	0.00	0.00	19.44	17.64
Sub-total: Commuting Vehicles	**2.46**	**0.25**	**0.07**	**0.00**	**0.08**	**0.03**	**0.00**	**19.03**	**0.00**	**0.00**	**19.44**	**17.64**
Total	**15.38**	**1.67**	**1.88**	**0.05**	**1.43**	**0.23**	**0.02**	**243.01**	**0.003**	**0.004**	**244.23**	**221.62**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative C

ALTERNATIVE: Alternative C

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.
[b] WRAP Fugitive Dust Handbook, September 2006.
Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year) PM_{10}	Emissions (tons/year) $PM_{2.5}$
Forest/Woodland Forest Products		112	2,240	31	12.73	1.27
				Total	**12.73**	**1.27**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	112.0	34.6	30	96.3	89.673	0.033	334.78	0	**0.04**	**0.00**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Forestry and Woodland Products - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions (lbs/year/activity)					Emissions (tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Skidder	205	1	70	8	31	248	368.99	42.17	10.04	304.39	36.14	1.8E-01	2.1E-02	5.0E-03	1.5E-01	1.8E-02	2.0E-02	2.3E+01	2.7E-04	2.4E-04
	Log Truck	450	1	60	10	31	310	810.09	45.43	21.28	325.00	41.21	4.1E-01	2.3E-02	1.1E-02	1.6E-01	2.1E-02	2.2E-02	4.9E+01	3.1E-04	5.6E-04
	Chainsaw	6	1	80	8	31	248	3.47	25.58	0.37	770.34	162.42	1.7E-03	1.3E-02	1.8E-04	3.9E-01	8.1E-02	1.2E-02	9.0E-01	7.1E-04	5.6E-06
	Feller Buncher	300	1	100	8	31	248	771.40	88.16	20.98	636.36	75.56	3.9E-01	4.4E-02	1.0E-02	3.2E-01	3.8E-02	4.3E-02	4.9E+01	5.7E-04	5.0E-04
	Loader	200	1	80	10	31	310	480.05	26.92	12.61	192.59	24.42	2.4E-01	1.3E-02	6.3E-03	9.6E-02	1.2E-02	1.3E-02	2.9E+01	1.9E-04	3.3E-04
	Dozer	200	1	90	8	31	248	432.05	24.23	11.35	173.34	21.98	2.2E-01	1.2E-02	5.7E-03	8.7E-02	1.1E-02	1.2E-02	2.6E+01	1.7E-04	3.0E-04
	Delimber	250	1	100	10	31	310	750.08	42.06	19.71	300.93	38.16	3.8E-01	2.1E-02	9.9E-03	1.5E-01	1.9E-02	2.0E-02	4.6E+01	2.9E-04	5.2E-04
												Total	**1.8E+00**	**1.5E-01**	**4.8E-02**	**1.4E+00**	**2.0E-01**	**1.4E-01**	**2.2E+02**	**2.5E-03**	**2.4E-03**

Source of activity data: Billings Field Office.

Assume 2008 emission factors for all years; this is a conservative estimate.

Forestry and Woodland Products - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved ro		50%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	30	31	930	1	930	1.32	0.61	2.46	0.13	0.06	0.25
	Log Truck	25	30	62	1,860	1	1,860	1.32	1.23		0.13	0.12	
	Pick-up Truck	25	30	31	930	1	930	1.32	0.61		0.13	0.06	
								Total	**2.46**			**0.25**	

Source of activity data: Billings Field Office.
Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle		Emission Factors (gm/mile)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions (tons/vehicle type)						Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	31	6,200	1	6,200	0.02	0.00	0.00	0.00	0.01	0.00	0.07	0.01	0.01	0.00	0.08	0.03	5.41	0.00	0.00
	Log Truck	HDDV	200	62	12,400	1	12,400	0.04	0.00	0.00	0.00	0.02	0.00							10.82	0.00	0.00
	Pick-up Truck	LDDT	200	31	6,200	1	6,200	0.02	0.00	0.00	0.00	0.04	0.02							2.80	0.00	0.00
							Total	**0.07**	**0.01**	**0.01**	**0.00**	**0.08**	**0.03**	**0.07**	**0.01**	**0.01**	**0.00**	**0.08**	**0.03**	**19.03**	**0.0008**	**0.0013**

Source of activity data: Billings Field Office.

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Forestry and Woodland Products - Alternative D

Forest Products **Alternative D**

Total Annual Emissions from Forest and Woodlands Projects - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	8.19	0.82	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.12	0.11	1.46	0.04	1.09	0.16	0.02	180.62	0.00	0.00	181.28	164.50
Sub-total: Heavy Equipment	**8.31**	**0.93**	**1.46**	**0.04**	**1.09**	**0.16**	**0.02**	**180.62**	**0.00**	**0.00**	**181.28**	**164.50**
Commuting Vehicles - Fugitive Dust	1.98	0.20	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.01	0.00	0.06	0.00	0.06	0.02	0.00	15.35	0.00	0.00	15.68	14.23
Sub-total: Commuting Vehicles	**1.99**	**0.20**	**0.06**	**0.00**	**0.06**	**0.02**	**0.00**	**15.35**	**0.00**	**0.00**	**15.68**	**14.23**
Total	**10.30**	**1.14**	**1.52**	**0.04**	**1.15**	**0.18**	**0.02**	**195.97**	**0.003**	**0.003**	**196.96**	**178.73**

[a] HAPs = Hazardous Air Pollutants (HAPs), which are assumed to account for 10 percent of VOC emissions.

Forestry and Woodland Products - Alternative D

ALTERNATIVE: Alternative D

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.
[b] WRAP Fugitive Dust Handbook, September 2006.
Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Forest Products - All Project Years

Forest Harvesting		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Project[1]	Emissions (tons/year) PM_{10}	Emissions (tons/year) $PM_{2.5}$
Forest/Woodland Forest Products		89	1,780	25	8.16	0.82
			Total		**8.16**	**0.82**

1. Land surface disturbed one time, so assume one day of disturbance for each acre.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Days with Precipitation >0.001 Inch	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(number)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	89.0	34.6	30	96.3	89.673	0.033	266.03	0	**0.03**	**0.00**

* Account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Forestry and Woodland Products - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Logging Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Log Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.003	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Forest and Woodland Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Project	Total Hours/ Project/ Year	Emissions													
								(lbs/year/activity)					(tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Skidder	205	1	70	8	25	200	297.57	34.01	8.09	245.48	29.15	1.5E-01	1.7E-02	4.0E-03	1.2E-01	1.5E-02	1.6E-02	1.9E+01	2.2E-04	1.9E-04
	Log Truck	450	1	60	10	25	250	653.30	36.64	17.16	262.10	33.23	3.3E-01	1.8E-02	8.6E-03	1.3E-01	1.7E-02	1.8E-02	4.0E+01	2.5E-04	4.5E-04
	Chainsaw	6	1	80	8	25	200	2.80	20.63	0.30	621.24	130.98	1.4E-03	1.0E-02	1.5E-04	3.1E-01	6.5E-02	9.5E-03	7.3E-01	5.7E-04	4.5E-06
	Feller Buncher	300	1	100	8	25	200	622.10	71.10	16.92	513.19	60.93	3.1E-01	3.6E-02	8.5E-03	2.6E-01	3.0E-02	3.4E-02	3.9E+01	4.6E-04	4.0E-04
	Loader	200	1	80	10	25	250	387.14	21.71	10.17	155.32	19.69	1.9E-01	1.1E-02	5.1E-03	7.8E-02	9.8E-03	1.1E-02	2.4E+01	1.5E-04	2.7E-04
	Dozer	200	1	90	8	25	200	348.42	19.54	9.15	139.79	17.72	1.7E-01	9.8E-03	4.6E-03	7.0E-02	8.9E-03	9.5E-03	2.1E+01	1.3E-04	2.4E-04
	Delimber	250	1	100	10	25	250	604.90	33.92	15.89	242.69	30.77	3.0E-01	1.7E-02	7.9E-03	1.2E-01	1.5E-02	1.6E-02	3.7E+01	2.3E-04	4.2E-04
												Total	1.5E+00	1.2E-01	3.9E-02	1.1E+00	1.6E-01	1.1E-01	1.8E+02	2.0E-03	2.0E-03

Source of activity data: Billings Field Office.

Assume 2008 emission factors for all years; this is a conservative estimate.

Forestry and Woodland Products - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved ro		50%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Vehicle Miles Traveled/ Project	# of Projects/Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/ vehicle type)	PM_{10} Emissions (tons/ activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/ vehicle type)	$PM_{2.5}$ Emissions (tons/ activity)
Forest/Woodland Forest Products	Support Truck	25	30	25	750	1	750	1.32	0.50	1.98	0.13	0.05	0.20
	Log Truck	25	30	50	1,500	1	1,500	1.32	0.99		0.13	0.10	
	Pick-up Truck	25	30	25	750	1	750	1.32	0.50		0.13	0.05	
								Total	**1.98**			**0.20**	

Source of activity data: Billings Field Office.
Assume application of water ~ 50% emissions control.

Forestry and Woodland Products - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Commuting Vehicles

Project Year	Emission Factors (gm/mile)								
	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/ Project	Vehicle Miles Traveled/ Project	# of Projects/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Forest/Woodland Forest Products	Support Truck	HDDV	200	25	5,000	1	5,000	0.01	0.00	0.00	0.00	0.01	0.00	0.06	0.01	0.00	0.00	0.06	0.02	4.36	0.00	0.00
	Log Truck	HDDV	200	50	10,000	1	10,000	0.03	0.00	0.00	0.00	0.02	0.00							8.73	0.00	0.00
	Pick-up Truck	LDDT	200	25	5,000	1	5,000	0.01	0.00	0.00	0.00	0.03	0.02							2.26	0.00	0.00
							Total	**0.06**	**0.01**	**0.00**	**0.00**	**0.06**	**0.02**	**0.06**	**0.01**	**0.00**	**0.00**	**0.06**	**0.02**	**15.35**	**0.0006**	**0.0010**

Source of activity data: Billings Field Office.

[a] All vehicles are diesel-powered, except ATVs, which are gasoline-powered.

Livestock Grazing - Alternatives A, B, C, and D

Livestock Grazing **Alternatives A-D**

Total Annual Emissions from Livestock Grazing Projects - Alternatives A-D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs [a]	CO_2	CH_4	N_2O	CO_{2eq}	CO_{2eq} metric Tons
Heavy Equipment - Fugitive Dust	0.39	0.04	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.02	0.02	0.29	0.01	0.12	0.02	0.00	29.80	0.00	0.00	29.9	**27.1**
Sub-total: Construction	**0.41**	**0.06**	**0.29**	**0.01**	**0.12**	**0.02**	**0.00**	**29.80**	**0.00**	**0.00**	**29.9**	**27.1**
Commuting Vehicles - Fugitive Dust	88.25	8.82	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.02	0.01	0.15	0.00	0.29	0.10	0.01	43.68	0.00	0.00	**44.6**	**40.5**
Enteric Fermentation and Manure Management	---	---	---	---	---	---	---	---	272.82	---	**5,729.3**	**5,199.0**
Sub-total: Operations and Maintenance	**88.26**	**8.83**	**0.15**	**0.00**	**0.29**	**0.10**	**0.01**	**43.68**	**272.83**	**0.00**	**5,773.9**	**5,239.5**
Total	**88.67**	**8.89**	**0.43**	**0.01**	**0.41**	**0.12**	**0.01**	**73.48**	**272.83**	**0.00**	**5,803.8**	**5,266.6**

[b] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	[illegible] month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emissions Estimation for Construction Activities - All Project Years

Construction Activity	Total Disturbed Acres/ Year	# of Days to Complete/ Year[1]	Emissions (tons/year)	
			PM_{10}	**$PM_{2.5}$**
Springs	1.00	1	3.67E-03	3.67E-04
Reservoirs/Pits	10.00	1	3.67E-02	3.67E-03
Wells	5.00	1	1.83E-02	1.83E-03
Pipelines	50.00	1	1.83E-01	1.83E-02
Fences	25.00	1	9.17E-02	9.17E-03
Reservoirs Maintenance	6.00	1	2.20E-02	2.20E-03
		Total	**3.56E-01**	**3.56E-02**

a information from Billings Field Office. Assumes no emissions controls.

1. assumes total acreage is disturbed once annually, so input one day for calculation purposes

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	97.0	34.6	30	89.673	0.033	289.94	0	**0.04**	**0.00**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:

p = number of days with > 0.001 in precipitation

f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs, Montana surface meteorology 2004-2011 dataset from Western Research Climate Center.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Exhaust Emission Factors for Diesel-Powered Off-Road Construction Equipment

Project Year/Hp Category	Emission Factors (g/hp-hr) NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Year 2008									
50 to 75	5.34	0.63	0.13	4.03	0.66	0.61	601.0	0.010	0.0061
75 to 100	5.36	0.65	0.13	4.15	0.66	0.63	600.5	0.010	0.0061
100 to 175	4.95	0.38	0.12	1.85	0.44	0.37	540.3	0.007	0.0061
175 to 300	4.37	0.29	0.11	1.46	0.36	0.28	506.7	0.006	0.0061
300 to 600	5.25	0.32	0.12	2.22	0.33	0.31	534.7	0.005	0.0061
600 to 750	5.24	0.32	0.11	2.54	0.31	0.31	534.6	0.005	0.0061
>750	6.47	0.34	0.11	2.19	0.46	0.33	533.8	0.007	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emissions Estimation for Construction Activities

Construction Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/Day	# of Days/ Project	# of Projects/ Year	Total Hours/ Unit/Year	Emissions (lbs/year) NO_x	PM_{10}	SO_2	CO	VOC	(tons/year) NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Springs	Backhoe	80	1	50	8	3	1.00	24.0	11	1	0	9	1	0.01	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00
Reservoirs/Pits	Bulldozer	500	1	70	8	3	2.00	48.0	194	12	4	82	12	0.10	0.01	0.00	0.04	0.01	0.01	9.90	0.00	0.00
	Scraper	650	1	70	8	3	2.00	48.0	253	15	6	107	16	0.13	0.01	0.00	0.05	0.01	0.01	12.87	0.00	0.00
Wells	Drill Rig	200	1	100	8	1	1.00	8.0	15	1	0	5	1	0.01	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.00
	Water Truck	200	1	70	8	1	1.00	8.0	11	1	0	4	1	0.01	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00
Pipelines	Dozer	200	1	75	1	1	1.00	1.0	2	0	0	1	0	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00
	Trencher	80	1	75	8	1	1.00	8.0	6	1	0	4	1	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00
	Backhoe	80	1	75	8	1	1.00	8.0	6	1	0	4	1	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00
Fences (Miles/yr.)	Auger Truck	250	1	75	8	1	2.00	16.0	29	2	1	10	2	0.01	0.00	0.00	0.00	0.00	0.00	1.68	0.00	0.00
Reservoir Maintenance	Bulldozer	500	1	70	2	3	2.00	12.0	49	3	1	21	3	0.02	0.00	0.00	0.01	0.00	0.00	2.48	0.00	0.00
													Total	**2.88E-01**	**1.83E-02**	**6.41E-03**	**1.23E-01**	**1.95E-02**	**1.78E-02**	**2.98E+01**	**2.98E-04**	**3.38E-04**

Source for activity data: Billings Field Office

all emissions calculated with year 2008 factors (conservative)

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Fugitive Dust from Commuting Vehicles on Unpaved Roads

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^{a}\,(S/30)^{d}}{(M/0.5)^{c}} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = emission control percent for watering unpaved roads[b]		50%	Billings Field Office.

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicle on Unpaved Roads - All Project Years

Construction Activity	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Project	Total Vehicle Miles/Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions[a] (tons/vehicle type)	PM_{10} Emissions[a] (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions[a] (tons/vehicle type)	$PM_{2.5}$ Emissions[a] (tons/activity)
Springs	Tractor-Trailer	35	75	2	150	1.00	150	1.56	0.12	0.23	0.16	0.01	0.02
	Pick-up Truck	35	75	2	150	1.00	150	1.56	0.12		0.16	0.01	
Reservoirs/Pits	Tractor-Trailer	35	75	3	225	2.00	450	1.56	0.35	0.70	0.16	0.04	0.07
	Pick-up Truck	35	75	3	225	2.00	450	1.56	0.35		0.16	0.04	
Wells	Drill Truck	35	75	3	225	1.00	225	1.56	0.18	0.70	0.16	0.02	0.07
	Support Truck	35	75	3	225	1.00	225	1.56	0.18		0.16	0.02	
	Water Truck	35	75	3	225	1.00	225	1.56	0.18		0.16	0.02	
	Pick-up Truck	35	75	3	225	1.00	225	1.56	0.18		0.16	0.02	
Pipelines	Tractor-Trailer	35	75	1	75	1.00	75	1.56	0.06	0.35	0.16	0.01	0.04
	Pick-up Truck	35	75	5	375	1.00	375	1.56	0.29		0.16	0.03	
Fences	Support Truck	35	75	1	75	2.00	150	1.56	0.12	1.17	0.16	0.01	0.12
	Pick-up Truck	35	75	4	300	2.00	600	1.56	0.47		0.16	0.05	
	ATV	35	75	5	375	2.00	750	1.56	0.59		0.16	0.06	
Reservoirs Maintenance	Tractor-Trailer	35	75	3	225	2.00	450	1.56	0.35	0.70	0.16	0.04	0.07
	Pick-up Truck	35	75	3	225	2.00	450	1.56	0.35		0.16	0.04	
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	35	75	1087	81525	1.00	81525	1.56	63.74	63.74	0.16	6.37	6.37
	Pick-up-Trailer (spring calves)	35	75	352	26400	1.00	26400	1.56	20.64	20.64	0.16	2.06	2.06
								Total	**88.25**			**8.82**	

Source for activity data: Billings Field Office, Larry Padden, 9-19-2011.

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission factors for Commuting Vehicles Exhaust

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
Light-Duty Gasoline Truck	LDGT2	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.053
Heavy-Duty Diesel Truck	HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: EPA MOBILE 6.2.03 use 2008 emission factors for all years = worst case

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Vehicle		Emission Factors (g/mi)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.18

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicle on Unpaved and Paved Roads - All Project Years

Construction Activity	Equipment Type	Class	Round Trip Distance (miles)	Round Trips per Project	Total Vehicle Miles per Project	# of Projects/Year	Total Annual Vehicle Miles Traveled	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Springs	Tractor-Trailer	HDDV	150	2	300	1.00	300.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.26	0.00	0.00
	Pick-up Truck	LDGT2	150	2	300	1.00	300.0	0.00	0.00	0.00	0.00	0.01	0.00							0.16	0.00	0.00
Reservoirs/Pits	Tractor-Trailer	HDDV	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.79	0.00	0.00
	Pick-up Truck	LDGT2	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.02	0.00							0.47	0.00	0.00
Wells	Drill Truck	HDDV	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.00	0.00	0.0046	0.0004	0.0003	0.0000	0.0145	0.0011	0.39	0.00	0.00
	Support Truck	HDDV	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.00	0.00							0.39	0.00	0.00
	Water Truck	HDDV	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.00	0.00							0.39	0.00	0.00
	Pick-up Truck	LDGT2	150	3	450	1.00	450.0	0.00	0.00	0.00	0.00	0.01	0.00							0.24	0.00	0.00
Pipelines	Tractor-Trailer	HDDV	150	1	150	1.00	150.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.13	0.00	0.00
	Pick-up Truck	LDGT2	150	5	750	1.00	750.0	0.00	0.00	0.00	0.00	0.02	0.00							0.39	0.00	0.00
Fences	Support Truck	HDDV	150	1	150	2.00	300.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.08	0.26	0.00	0.00
	Pick-up Truck	LDGT2	150	4	600	2.00	1,200.0	0.00	0.00	0.00	0.00	0.03	0.00							0.63	0.00	0.00
	ATV	R12S	150	5	750	2.00	1,500.0	0.00	0.00	0.00	0.00	0.08	0.08							0.23	0.00	0.00
Reservoirs Maintenance	Tractor-Trailer	HDDV	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.79	0.00	0.00
	Pick-up Truck	LDGT2	150	3	450	2.00	900.0	0.00	0.00	0.00	0.00	0.02	0.00							0.47	0.00	0.00
Livestock Management	Tractor-Trailer (spring turnout, fall gather)	HDDV	30	1087	32610	1.00	32,610.0	0.10	0.01	0.01	0.00	0.06	0.01	0.13	0.01	0.01	0.00	0.08	0.02	28.46	0.00	0.00
	Pcik-up-Trailer (spring calves)	HDDV	30	352	10560	1.00	10,560.0	0.03	0.00	0.00	0.00	0.02	0.00							9.22	0.00	0.00
													TOTAL	**0.15**	**0.02**	**0.01**	**0.00**	**0.29**	**0.10**	**43.68**	**0.00**	**0.00**

Source for activity data: Billings Field Office

Livestock Grazing - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

CH4 Emissions from Enteric Fermentation and Manure Management

Methane Emission Factors					
Livestock		Enteric Fermentation (Kg/head/yr)	Enteric Fermentation (lb/head/yr)	Manure Management (Kg/head/yr)	Manure Management (lb/head/yr)
Cattle	includes bulls, yearlings, and calves	53	116.84	2	4.41
Horse		18	39.68	2.34	5.16
Sheep		8	17.64	0.28	0.62

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry, and Other Land Use, Chapter 10 Emissions From Livestock and Manure Management

Methane Emissions from Livestock - All Project Years

Livestock Category	Animal Unit Months (AUM) per Year	Enteric Fermentation emission factor (lb/head/month)	Annual Methane Emissions from Enteric Fermentation (tons/yr)	Manure Management emission factor (lb/head/month)	Annual Methane Emissions from Manure Management (tons/yr)	Total Methane Emissions (tons/yr)
Cattle	53,776	9.74	261.80	0.37	9.88	271.68
Horse	274	3.31	0.45	0.43	0.06	0.51
Sheep	823	1.47	0.60	0.05	0.02	0.63
					Total Methane emissions	**272.82**

BiFO total AUMs (excluding suspended units) are 54,873 for each Alternative. More than 97% of allocations are for cattle, with the remainder for sheep and horses. Because cattle authorizations are larger than sheep and horse authorizations, cattle/sheep/horse AUMs are estimated to be 99%/0.75%/0.25 respectively. Total AUMs and authorization numbers provided by Larry Padden on 9-19-2011.

Recreation and Visitor Services - Alternatives A, B, C, and D

Trails and Travel Management **Alternatives A-D**

Total Annual Emissions from Trails and Travel Managment - Alternatives A-D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Recreation Vehicles - Fugitive Dust	226.76	22.66	---	---	---	---	---	---	---	---	---	---
Recreation Vehicles - Vehicle Exhaust	0.16	0.14	0.24	0.00	8.64	0.86	0.09	106.41	0.05	0.036	118.51	107.54
Sub-total: Vehicles	**226.92**	**22.80**	**0.24**	**0.00**	**8.64**	**0.86**	**0.09**	**106.41**	**0.05**	**0.04**	**118.51**	**107.54**
Total	**226.92**	**22.80**	**0.24**	**0.00**	**8.64**	**0.86**	**0.09**	**106.41**	**0.048**	**0.036**	**118.51**	**107.54**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Recreation and Visitor Services - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Billings Field Office, Dustin Crowe email dated August 16, 2010.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	Billings, MT Climate Summary from 1961-1990, Western Regional Climate Center.
CE = control percent for applying dust suppressant to unpaved roads [b]		0%	No control

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

Fugitive Dust Emission Estimations for Recreation Vehicles on Unpaved Roads - All Project Years

Activity Location	Equipment Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	Number of Trips	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/year)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/year)
Shapard Ah-Nei	ATV	15	25	365	9,113	2.05	9.33	45.74	0.20	0.93	4.57
	Off-Road Motorcyles	25	25	365	9,113	2.64	12.04		0.26	1.20	
	Pickup Truck	40	10	1458	14,580	3.34	24.37		0.33	2.44	
South Hills	ATV	15	10	900	9,000	2.05	9.21	27.12	0.20	0.92	2.71
	Off-Road Motorcyles	25	10	900	9,000	2.64	11.89		0.26	1.19	
	Pickup Truck	40	2	1800	3,600	3.34	6.02		0.33	0.60	
Pryor Mountain	ATV	15	30	306	9,180	2.05	9.40	135.96	0.20	0.94	13.59
	Off-Road Motorcyles	25	60	306	18,360	2.64	24.26		0.26	2.42	
	Pickup Truck	40	60	1020	61,200	3.34	102.30		0.33	10.22	
Elk Basin Motorcycle Race	ATV	15	0	0	0	2.05	0.00	17.94	0.20	0.00	1.79
	Off-Road Motorcyles	50	75	125	9,375	3.74	17.52		0.37	1.75	
	Pickup Truck	40	2	125	250	3.34	0.42		0.33	0.04	
							Total	226.76			22.66

Source of activity data: Craid Drake, Miles City Field Office, based on the following: Shepard Ah-Nei 1,358 daily passes and 10 annual passes (10 trips per year); South Hills 10 motorcycles per day for 6 months/yr; Pryor Mountain 1,020 estimated round trips; Elk Bas Motorcycle Race with 125 participants. ATV and motorcycle use are assumed to be evenly split for non-race activities.

Recreation and Visitor Services - Alternatives A, B, C, and D

ALTERNATIVE: Alternatives A-D

Emission Factors for Off-Road Recreation Vehicles

Vehicle	Emission Factors (gm/mile)								
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003
Gasoline Light-Duty Truck	LDDT	1.13	0.03	0.01	0.01	23.97	1.07	476.9	0.07	0.18

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17.

Combustive Emission Estimations for Recreation Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Tripsper Year	Total Annual Vehicle Miles Traveled	Emissions (tons/year)								
						NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Shapard Ah-Nei	ATV	R12S	25	365	9,113	0.00	0.02	0.02	0.00	0.48	0.49	1.41	0.00	0.00
	Off-Road Motorcyles	R12S	25	365	9,113	0.00	0.02	0.02	0.00	0.48	0.49	1.41	0.00	0.00
	Pickup Truck	LDDT	40	1458	58,320	0.07	0.00	0.00	0.00	1.54	0.07	30.66	0.00	0.01
South Hills	ATV	R12S	10	900	9,000	0.00	0.02	0.02	0.00	0.47	0.48	1.39	0.00	0.00
	Off-Road Motorcyles	R12S	10	900	9,000	0.00	0.02	0.02	0.00	0.47	0.48	1.39	0.00	0.00
	Pickup Truck	LDDT	20	1800	36,000	0.04	0.00	0.00	0.00	0.95	0.04	18.92	0.00	0.01
Pryor Mountain	ATV	R12S	30	306	9,180	0.00	0.02	0.02	0.00	0.48	0.49	1.42	0.00	0.00
	Off-Road Motorcyles	R12S	60	306	18,360	0.01	0.04	0.03	0.00	0.97	0.99	2.84	0.01	0.00
	Pickup Truck	LDDT	80	1020	81,600	0.10	0.00	0.00	0.00	2.16	0.10	42.90	0.01	0.02
Elk Basin Motorcycle Race	ATV	R12S	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Off-Road Motorcyles	R12S	75	125	9,375	0.00	0.02	0.02	0.00	0.49	0.50	1.45	0.00	0.00
	Pickup Truck	LDDT	40	125	5,000	0.01	0.00	0.00	0.00	0.13	0.01	2.63	0.00	0.00
					Total	0.24	0.16	0.14	0.00	8.64	4.14	106.41	0.05	0.04

Source of activity data: Craid Drake, Miles City Field Office, based on the following: Shepard Ah-Nei 1,358 daily passes and 10 annual passes (10 trips per year); South Hills 10 motorcycles per day for 6 months/yr; Pryor Mountain 1,020 estimated round trips; Elk Basin Motorcycle Race with 125 participants. ATV and motorcycle use are assumed to be evenly split for non-race activities.

Vegetation Management Resource - Alternative A

Weed Treatment **Alternative A**

Total Annual Emissions for Weed Treatment - RMP Year - Alternative A

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	11.09	1.11	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.09	0.09	0.01	0.00	2.80	0.59	0.06	6.53	0.01	0.00	6.65	6.04
Sub-total: Heavy Equipment	**11.18**	**1.19**	**0.01**	**0.00**	**2.80**	**0.59**	**0.06**	**6.53**	**0.01**	**0.0000**	**6.65**	**6.04**
Commuting Vehicles - Fugitive Dust	2.48	0.25	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.02	0.00	0.11	0.08	0.01	3.69	0.00	0.00	3.84	3.49
Sub-total: Commuting Vehicles	**2.48**	**0.25**	**0.02**	**0.00**	**0.11**	**0.08**	**0.01**	**3.69**	**0.00**	**0.0005**	**3.84**	**3.49**
Total	**13.66**	**1.44**	**0.03**	**0.00**	**2.91**	**0.67**	**0.07**	**10.22**	**0.01**	**0.000**	**10.49**	**9.52**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Vegetation Management Resource - Alternative A

ALTERNATIVE: Alternative A

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS

Description	Value	Source	Notes
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors*, Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Weed Treatment - All Project Years

Construction Activity		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year) PM_{10}	Emissions (tons/year) $PM_{2.5}$
Weed Treatment		2744	54,880	1	10.06	1.01
				Total	**10.06**	**1.01**

1. Input for calculation purposes, land disturbed one time per year.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	2744.0	34.6	30	89.673	0.033	8,202.13	0	**1.03**	**0.10**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
p = number of days with > 0.001 in precipitation
f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Vegetation Management Resource - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Equipment

	Emission Factors (g/hp-hr)								
Year 2008	**NOx**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O[1]**
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Heavy Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.00	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Weed Management Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Activity	Total Hours/ Activity/Year	Emissions (lbs/year/activity)					Emissions (tons/year)									
								NO_x	**PM_{10}**	**SO_2**	**CO**	**VOC**	**NO_x**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O**
Weed Treatment	Spray Vehicle	40	---	100	---	---	216	25.20	185.68	2.67	5,591.15	1,178.83	0.01	0.09	0.00	2.80	0.59	0.09	6.53	0.01	0.00
	Spray Unit	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
												Total	**1.26E-02**	**9.28E-02**	**1.34E-03**	**2.80E+00**	**5.89E-01**	**8.54E-02**	**6.53E+00**	**5.13E-03**	**4.09E-05**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Hours estimated by dividing total vehicle miles traveled by speed.
Assume 2008 emission factors for all years = conservative estimate

Vegetation Management Resource - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Source of activity data: Billings Field Office.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		0%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/activity)
Weed Treatment	ATV and Other Equipment	5	---	---	4,200	1	4,200	1.18	2.48	2.48	0.12	0.25	0.25
								Total	**2.48**			**0.25**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

a Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative A

ALTERNATIVE: Alternative A

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions (tons/vehicle type)						Emissions (tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Weed Treatment	ATV	R12S	---	---	---	---	1,080	0.00	0.00	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00	0.06	0.06	0.17	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	7,800	0.02	0.00	0.00	0.00	0.05	0.02	0.02	0.00	0.00	0.00	0.05	0.02	3.52	0.00	0.00
							Total	**0.02**	**0.00**	**0.00**	**0.00**	**0.11**	**0.08**	**0.02**	**0.00**	**0.00**	**0.00**	**0.11**	**0.08**	**3.69**	**0.00**	**0.000**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled.

a All vehicles are diesel-powered, except the ATVs, which are gasoline-powered.

Vegetation Management Resource - Alternative B

Weed Treatment **Alternative B**

Total Annual Emissions for Weed Treatment - RMP Year - Alternative B

	Annual Emissions (Tons)											
Activity	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	1.87	0.19	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.02	0.01	0.00	0.00	0.48	0.10	0.01	1.11	0.00	0.00	1.13	1.03
Sub-total: Heavy Equipment	**1.89**	**0.20**	**0.00**	**0.00**	**0.48**	**0.10**	**0.01**	**1.11**	**0.00**	**0.0000**	**1.13**	**1.03**
Commuting Vehicles - Fugitive Dust	0.42	0.04	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.63	0.00	0.00	0.65	0.59
Sub-total: Commuting Vehicles	**0.42**	**0.04**	**0.00**	**0.00**	**0.02**	**0.01**	**0.00**	**0.63**	**0.00**	**0.0001**	**0.65**	**0.59**
Total	**2.31**	**0.24**	**0.01**	**0.00**	**0.49**	**0.11**	**0.01**	**1.74**	**0.00**	**0.000**	**1.78**	**1.62**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Vegetation Management Resource - Alternative B

ALTERNATIVE: Alternative B

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS

Description	Value	Source	Notes
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors*, Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Weed Treatment - All Project Years

Construction Activity		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year) PM_{10}	Emissions (tons/year) $PM_{2.5}$
Weed Treatment		464	9,280	1	1.70	0.17
				Total	**1.70**	**0.17**

1. Input for calculation purposes, land disturbed one time per year.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	464.0	34.6	30	89.673	0.033	1,386.95	0	**0.17**	**0.02**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.

* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:

p = number of days with > 0.001 in precipitation

f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.

* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.

* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Vegetation Management Resource - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Heavy Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.00	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Weed Management Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Activity	Total Hours/ Activity/Year	Emissions (lbs/year/activity)					Emissions (tons/year)									
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Weed Treatment	Spray Vehicle	40	---	100	---	---	37	4.28	31.57	0.45	950.50	200.40	0.00	0.02	0.00	0.48	0.10	0.01	1.11	0.00	0.00
	Spray Unit	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
												Total	**2.14E-03**	**1.58E-02**	**2.27E-04**	**4.75E-01**	**1.00E-01**	**1.45E-02**	**1.11E+00**	**8.72E-04**	**6.95E-06**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Hours estimated by dividing total vehicle miles traveled by speed.

Assume 2008 emission factors for all years = conservative estimate

Vegetation Management Resource - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Source of activity data: Billings Field Office.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		0%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/activity)
Weed Treatment	ATV and Other Equipment	5	---	---	714	1	714	1.18	0.42	0.42	0.12	0.04	0.04
								Total	**0.42**			**0.04**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

a Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative B

ALTERNATIVE: Alternative B

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Weed Treatment	ATV	R12S	---	---	---	---	184	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	1,326	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.60	0.00	0.00
							Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.01**	**0.63**	**0.00**	**0.000**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled scaled from Alternative A based on the ratio of treated acreage. Alternative B acreage is 17% of Alternative A acreage.

a All vehicles are diesel-powered, except the ATVs, which are gasoline-powered.

Vegetation Management Resource - Alternative C

Weed Treatment **Alternative C**

Total Annual Emissions for Weed Treatment - RMP Year - Alternative C

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	8.44	0.84	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.07	0.06	0.01	0.00	2.12	0.45	0.04	4.97	0.00	0.00	5.06	4.59
Sub-total: Heavy Equipment	**8.51**	**0.91**	**0.01**	**0.00**	**2.12**	**0.45**	**0.04**	**4.97**	**0.00**	**0.0000**	**5.06**	**4.59**
Commuting Vehicles - Fugitive Dust	1.89	0.19	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.02	0.00	0.08	0.06	0.01	2.80	0.00	0.00	2.92	2.65
Sub-total: Commuting Vehicles	**1.89**	**0.19**	**0.02**	**0.00**	**0.08**	**0.06**	**0.01**	**2.80**	**0.00**	**0.0003**	**2.92**	**2.65**
Total	**10.40**	**1.10**	**0.02**	**0.00**	**2.21**	**0.51**	**0.05**	**7.77**	**0.00**	**0.000**	**7.98**	**7.24**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Vegetation Management Resource - Alternative C

ALTERNATIVE: Alternative C

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS

Description	Value	Source	Notes
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors*, Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Weed Treatment - All Project Years

Construction Activity		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year) PM_{10}	Emissions (tons/year) $PM_{2.5}$
Weed Treatment		2088	41,760	1	7.66	0.77
				Total	**7.66**	**0.77**

1. Input for calculation purposes, land disturbed one time per year.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	2088.0	34.6	30	89.673	0.033	6,241.27	0	**0.78**	**0.08**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
 p = number of days with > 0.001 in precipitation
 f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Vegetation Management Resource - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Equipment

	Emission Factors (g/hp-hr)								
Year 2008	**NOx**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O[1]**
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Heavy Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.00	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Weed Management Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Activity	Total Hours/ Activity/Year
Weed Treatment	Spray Vehicle	40	---	100	---	---	164
	Spray Unit	0	0	0	0	0	0

Emissions (lbs/year/activity)					Emissions (tons/year)								
NO_x	**PM_{10}**	**SO_2**	**CO**	**VOC**	**NO_x**	**PM_{10}**	**SO_2**	**CO**	**VOC**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_2O**
19.15	141.12	2.03	######	895.91	0.01	0.07	0.00	2.12	0.45	0.06	4.97	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				Total	**9.58E-03**	**7.06E-02**	**1.01E-03**	**2.12E+00**	**4.48E-01**	**6.49E-02**	**4.97E+00**	**3.90E-03**	**3.11E-05**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Hours estimated by dividing total vehicle miles traveled by speed.
Assume 2008 emission factors for all years = conservative estimate

Vegetation Management Resource - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$E_{ext} = E\,(1 - P/365)$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Source of activity data: Billings Field Office.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		0%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/activity)
Weed Treatment	ATV and Other Equipment	5	---	---	3,192	1	3,192	1.18	1.89	1.89	0.12	0.19	0.19
								Total	**1.89**			**0.19**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

a Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative C

ALTERNATIVE: Alternative C

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles Traveled/ Activity	Emissions														
								(tons/vehicle type)						(tons/year)								
								NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Weed Treatment	ATV	R12S	---	---	---	---	821	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.04	0.04	0.13	0.00	0.00
Weed Treatment	Other Equipment	LDDT	---	---	---	---	5,928	0.02	0.00	0.00	0.00	0.04	0.02	0.02	0.00	0.00	0.00	0.04	0.02	2.68	0.00	0.00
							Total	**0.02**	**0.00**	**0.00**	**0.00**	**0.08**	**0.06**	**0.02**	**0.00**	**0.00**	**0.00**	**0.08**	**0.06**	**2.80**	**0.00**	**0.000**

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled scaled from Alternative A based on the ratio of treated acreage. Alternative C acreage is 76% of Alternative A acreage.

a All vehicles are diesel-powered, except the ATVs, which are gasoline-powered.

Vegetation Management Resource - Alternative D

Weed Treatment **Alternative D**

Total Annual Emissions for Weed Treatment - RMP Year - Alternative D

Activity	Annual Emissions (Tons)											
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	VOC	HAPs[a]	CO_2	CH_4	N_2O	$CO2_{eq}$ tons	$CO2_{eq}$ metric tons
Heavy Equipment - Fugitive Dust	4.50	0.45	---	---	---	---	---	---	---	---	---	---
Heavy Equipment - Vehicle Exhaust	0.04	0.04	0.01	0.00	1.15	0.24	0.02	2.68	0.00	0.00	2.73	2.48
Sub-total: Heavy Equipment	**4.54**	**0.49**	**0.01**	**0.00**	**1.15**	**0.24**	**0.02**	**2.68**	**0.00**	**0.0000**	**2.73**	**2.48**
Commuting Vehicles - Fugitive Dust	1.02	0.10	---	---	---	---	---	---	---	---	---	---
Commuting Vehicles - Vehicle Exhaust	0.00	0.00	0.01	0.00	0.05	0.03	0.00	1.51	0.00	0.00	1.57	1.43
Sub-total: Commuting Vehicles	**1.02**	**0.10**	**0.01**	**0.00**	**0.05**	**0.03**	**0.00**	**1.51**	**0.00**	**0.0002**	**1.57**	**1.43**
Total	**5.56**	**0.59**	**0.01**	**0.00**	**1.19**	**0.28**	**0.03**	**4.19**	**0.00**	**0.000**	**4.30**	**3.90**

[a] HAPs = Hazardous Air Pollutants; assumed = VOCs * 0.1

Vegetation Management Resource - Alternative D

ALTERNATIVE: Alternative D

Fugitive Dust from Heavy Construction Operations

INPUTS & ASSUMPTIONS			
Description	**Value**	**Source**	**Notes**
Control Efficiency (C) of watering[a]	0	a	
PM_{10} Emission Factor	0.11	b	Tons PM_{10}/acre-month
Conversion factor for PM_{10} to $PM_{2.5}$	0.1	c	Percentage of PM_{10}

[a] The PM_{10} emission factor shown below includes 50% control based on watering.

[b] WRAP Fugitive Dust Handbook, September 2006.

[c] Midwest Research Institute. 2006. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* , Report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, November 1, 2006.

Fugitive Dust Emission Estimations for Weed Treatment - All Project Years

Construction Activity		Total Disturbed Acres/Year	Total Disturbed Acres (20 years)	# of Days to Complete/ Activity[1]	Emissions (tons/year) PM_{10}	Emissions (tons/year) $PM_{2.5}$
Weed Treatment		1114	22,280	1	4.08	0.41
				Total	**4.08**	**0.41**

1. Input for calculation purposes, land disturbed one time per year.

Wind Erosion Associated with Land Disturbance

Activity	Land Area Disturbed	Silt Content	Days with Wind Speed Greater Than 5.4 m/s	Total Suspended Particulate	Months to Disturb Total Area	Total Suspended Particulate	Emission Control Percent	PM_{10} Emissions	$PM_{2.5}$ Emissions
	(acre/year)	(%)	(%)	(lbs/acre/month)	(months)	(lbs/year)	(%)	(tons/year)	(tons/year)
Total Land Disturbance	1114.0	34.6	30	89.673	0.033	3,329.87	0	**0.42**	**0.04**

* account for wind blown dust occuring one time (day) for the disturbed land area (includes disturbed road ways), therefore input one day for calculation purposes.
* "Control of Fugitive Dust Sources" EPA-450/3-98-008 (EPA 1998). TSP (lb/acre/month) = 1.7 × (s/1.5) × ([365-p]/235) × (f/15), where:
  p = number of days with > 0.001 in precipitation
  f = percent of time wind speed exceeds 5.4 (m/s) [equivalent to 12 mph] = 30.0% derived from Soda Springs Mountain, Montana surface meteorology 2004-2010 dataset.
* AP-42 (EPA 2006), Section 13.2.2 "Unpaved Roads", Background Document. Assuming that PM10 accounts for 25% of TSP. Daily and hourly emissions based on 30.4-day month.
* Assuming that $PM_{2.5}$ accounts for 10% of PM_{10} based on "Analysis of the Fine Fraction of PM in Fugitive Dust," Midwest Research Institute (MRI) Report 110397 (2005).

Vegetation Management Resource - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Equipment

	Emission Factors (g/hp-hr)								
Year 2008	NOx	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O[1]
Chainsaw 6-11 Hp	1.32	9.75	0.14	293.54	61.89	8.97	686.00	0.54	0.0043
Feller/Bunch/Skidder 75-100	4.70	0.54	0.13	3.88	0.46	0.52	594.76	0.01	0.0061
Heavy Equipp 300 Hp	4.39	0.25	0.12	1.76	0.22	0.24	536.15	0.00	0.0061

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Weed Management Activities - All Years

Activity	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Hours/ Day	# of Days/ Activity	Total Hours/ Activity/Year	Emissions													
								(lbs/year/activity)					(tons/year)								
								NO_x	PM_{10}	SO_2	CO	VOC	NO_x	PM_{10}	SO_2	CO	VOC	$PM_{2.5}$	CO_2	CH_4	N_2O
Weed Treatment	Spray Vehicle	40	---	100	---	---	89	10.33	76.13	1.09	2,292.37	483.32	0.01	0.04	0.00	1.15	0.24	0.04	2.68	0.00	0.00
	Spray Unit	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
												Total	5.17E-03	3.81E-02	5.47E-04	1.15E+00	2.42E-01	3.50E-02	2.68E+00	2.10E-03	1.68E-05

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Hours estimated by dividing total vehicle miles traveled by speed.

Assume 2008 emission factors for all years = conservative estimate

Vegetation Management Resource - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Publicly Accessible Unpaved Roads[a]

$$E\ (lb/VMT) = \frac{k\,(s/12)^a\,(S/30)^d}{(M/0.5)^c} - C$$

$$E_{ext} = E\,(1 - P/365)$$

Parameter	PM_{10}	$PM_{2.5}$
k	1.8	0.18
a	1	1
d	0.5	0.5
c	0.2	0.2

Function/Variable Description		Assumed Value	Reference
E = size-specific emission factor (lb/VMT)			
E_{ext} = size-specific emission factor extrapolated for natural mitigation (lb/VMT)			
s = surface material silt content (%)		34.6	Source of activity data: Billings Field Office.
S = mean vehicle speed (mph)			
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)	$PM_{2.5}$	0.00036	EPA AP-42 Section 13.2.2, Table 13.2.2-4
	PM_{10}	0.00047	EPA AP-42 Section 13.2.2, Table 13.2.2-4
M = surface material moisture content (%)		2.0	EPA AP-42 Section 13.2.2
P = Number of days precip per year		96.3	EPA AP-42 Section 13.2.2, Figure 13.2.2-1
CE = control efficiency of watering [b]		0%	

[a] *Source: EPA, AP-42 Volume I, Section 13.2.2 Unpaved Roads, Table 13.2.2-2, Nov. 2006*

[b] Fitzpatrick, M. 1990. *User's Guide: Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions*, EPA/625/5-87/022. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20008SFC.

Fugitive Dust Emission Estimations for Commuting Vehicles on Unpaved Roads - All Project Years

Activity	Equipment Type[a]	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/ Activity	Vehicle Miles Traveled/ Activity	# of Activities/ Year	Total Annual Vehicle Miles	PM_{10} Controlled Em. Factor (lb/VMT)	PM_{10} Emissions (tons/vehicle type)	PM_{10} Emissions (tons/activity)	$PM_{2.5}$ Controlled Em. Factor (lb/VMT)	$PM_{2.5}$ Emissions (tons/vehicle type)	$PM_{2.5}$ Emissions (tons/activity)
Weed Treatment	ATV and Other Equipment	5	---	---	1,722	1	1,722	1.18	1.02	1.02	0.12	0.10	0.10
								Total	**1.02**			**0.10**	

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled. VMT is equal to total ATV travel (all on unpaved roads) plus 40% of total truck travel.

Assume no watering

a Accounts for Billings Field Office. "other" equipment associated with this project.

Vegetation Management Resource - Alternative D

ALTERNATIVE: Alternative D

Emission Factors for Commuting Vehicles

	Emission Factors (gm/mile)								
Project Year	NO_x	PM_{10}	$PM_{2.5}$	SO2	CO	VOC	CO_2	CH_4	N_2O[1]
2008									
LDDT	2.31	0.11	0.09	0.01	6.25	2.75	409.5	0.002	0.053
HDDV	2.72	0.28	0.23	0.01	1.72	0.35	791.8	0.04	0.04

Source: Moblie 6.2.03

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Emission Factors for Off-Road ATV

Vehicle	Emission Factors (gm/mile)									
Type	Class	NO_x	PM_{10}	$PM_{2.5}$	SO_x	CO	VOC	CO_2	CH_4	N_2O[1]
2-Stroke ATV	R12S	0.25	1.86	1.71	0.03	47.81	48.72	140.15	0.42	0.003

Source: EPA NONROADS 2008a

1. N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Combustive Emission Estimations for Commuting Vehicles on Unpaved and Paved Roads - All Project Years

Activity	Equipment Type[a]	Class	Round Trip Distance (miles)	# of Round Trips/Activity	Vehicle Miles Traveled/ Activity	# of Activities/Year	Total Annual Vehicle Miles Traveled/ Activity
Weed Treatment	ATV	R12S	---	---	---	---	443
Weed Treatment	Other Equipment	LDDT	---	---	---	---	3,198
Total							

	Emissions														
	(tons/vehicle type)						(tons/year)								
Activity	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	VOC	CO_2	CH_4	N_2O
Weed Treatment (ATV)	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.07	0.00	0.00
Weed Treatment (Other Equipment)	0.01	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.02	0.01	1.44	0.00	0.00
Total	8.27E-03	1.29E-03	1.15E-03	3.34E-05	4.54E-02	3.35E-02	8.27E-03	1.29E-03	1.15E-03	3.34E-05	4.54E-02	3.35E-02	#######	2.14E-04	1.88E-04

Source of activity data: Billings Field Office, Melissa Passes, 9-20-2011. Data provided in terms of total vehicle miles traveled scaled from Alternative A based on the ratio of treated acreage. Alternative D treated acreage is 41% of Alternative A treated acreage.

[a] All vehicles are diesel-powered, except the ATVs, which are gasoline-powered.

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Appendix Z:
Discussion of Proper Functioning Condition

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Z. PFC – PROPER FUNCTIONING CONDITION

Z.1 WHAT IT IS - WHAT IT ISN'T

PFC is: A methodology for assessing the physical functioning of riparian and wetland areas. The term PFC is used to describe both the **assessment** process, and a defined, on-the-ground **condition** of a riparian-wetland area. In either case, PFC defines a minimum or starting point.

The PFC **assessment** provides a consistent approach for assessing the physical functioning of riparian-wetland areas through consideration of hydrology, vegetation, and soil/landform attributes. The PFC assessment synthesizes information that is foundational to determining the overall health of a riparian-wetland area.

The on-the-ground **condition** termed PFC refers to how well the physical processes are functioning. PFC is a state of resiliency that will allow a riparian wetland system to hold together during a 25 to 30 year flow event, sustaining that system's ability to produce values related to both physical and biological attributes.

PFC isn't: The sole methodology for assessing the health of the aquatic or terrestrial components of a riparian-wetland area.

PFC isn't: A replacement for inventory or monitoring protocols designed to yield information on the "biology" of the plants and animals dependent on the riparian-wetland area.

PFC can: Provide information on whether a riparian-wetland area is physically functioning in a manner which will allow the maintenance or recovery of desired values, e.g., fish habitat, neotropical birds, or forage, over time.

PFC isn't: Desired (future) condition. It is a prerequisite to achieving desired condition.

PFC can't: Provide more than strong clues as to the actual condition of habitat for plants and animals. Generally a riparian-wetland area in a physically nonfunctioning condition will not provide quality habitat conditions. A riparian wetland area that has recovered to a proper functioning condition would either be providing quality habitat conditions, or would be moving in that direction if recovery is allowed to continue. A riparian-wetland area that is functioning-at-risk would likely lose any habitat that exists in a 25 to 30 year flow event.

Therefore: To obtain a complete picture of riparian-wetland area health, including the biological side, one must have information on both physical status, provided through the PFC assessment, and biological habitat quality. Neither will provide a complete picture when analyzed in isolation. In most cases proper functioning condition will be a prerequisite to achieving and maintaining habitat quality.

PFC is: A useful tool for prioritizing restoration activities. By concentrating on the "at risk" systems, restoration activities can save many riparian-wetland areas from degrading to a non functioning condition. Once a system is non functional the effort, cost, and time required for recovery is dramatically increased. Restoration of non functional systems should be reserved for those situations where the riparian wetland has reached a point where recovery is possible, when efforts are not at the expense of "at risk" systems, or when unique opportunities exist. At the same time, systems that are properly functioning are not the highest priorities for restoration. Management of these systems should be continued to maintain PFC and further recovery towards desired condition.

PFC is: A useful tool for determining appropriate timing and design of riparian-wetland restoration projects (including structural and management changes). It can identify situations where instream structures are either entirely inappropriate or premature.

PFC is: A useful tool that can be used in watershed analysis. While the methodology and resultant data is "reach based", the ratings can be aggregated and analyzed at the watershed scale. PFC, along with other watershed and habitat condition information helps provide a good picture of watershed health and the possible causal factors affecting watershed health. Use of PFC will help to identify watershed scale problems and suggest management remedies and priorities.

PFC isn't: Watershed analysis in and of itself, or a replacement for watershed analysis.

PFC is: A useful tool for designing implementation and effectiveness monitoring plans. By concentrating implementation monitoring efforts on the "no" answers, greater efficiency of resources (people, dollars, time) can be achieved. The limited resources of the local manager in monitoring riparian-wetland parameters can be prioritized to those factors that are currently "out of range" or at risk of going out of range. The role of research may extend to validation monitoring of many of the parameters.

PFC wasn't: Designed to be a long term monitoring tool but it may be an appropriate part of a well designed monitoring program.

PFC isn't: Designed to provide monitoring answers about attainment of desired conditions. However, it can be used to provide a thought process on whether a management strategy is likely to allow attainment of desired conditions.

PFC can: Reduce the frequency and sometimes the extent of more data and labor intensive inventories. PFC can reduce process by concentrating efforts on the most significant problem areas first and thereby increasing efficiency.

PFC can't: Eliminate the need for more intensive inventory and monitoring protocols. These will often be needed to validate that riparian-wetland area recovery is indeed moving toward or has achieved desired conditions, e.g., good quality habitat; or simply establish what the existing habitat quality is.

PFC is: A qualitative assessment based on quantitative science. The PFC assessment is intended for individuals with local, on-the-ground experience in the kind of quantitative sampling techniques that support the checklist. These quantitative techniques are encouraged in conjunction with the PFC assessment for individual calibration, where answers are uncertain, or where experience is limited. PFC is also an appropriate starting point for determining and prioritizing the type and location of quantitative inventory or monitoring necessary.

PFC isn't: A replacement for quantitative inventory or monitoring protocols. PFC is meant to complement more detailed methods by providing a way to synthesize data and communicate results.

Z.2 PFC Checklist

The following section contains the PFC checklist as used by BLM staff and others in the field. Immediately following are the general instructions, and then the two pages of the checklist itself.

Z.3 General Instructions

1) The concept "**Relative to Capability**" applies wherever it may be inferred.
2) This checklist constitutes the **Minimum National Standards** required to determine Proper Functioning Condition of lotic riparian-wetland areas.
3) As a minimum, an **ID Team** will use this checklist to determine the degree of function of a riparian-wetland area.
4) Mark one box for each element. Elements are numbered for the purpose of cataloging comments. The numbers do not declare importance.
5) For any item marked "**No**," the severity of the condition must be explained in the "**Remarks**" section and must be a subject for discussion with the ID Team in determining riparian-wetland functionality. Using the "**Remarks**" section to also explain items marked "**Yes**" is encouraged but not required.
6) Based on the ID Team's discussion, "**functional rating**" will be resolved and the checklist's summary section will be completed.
7) Establish photo points where possible to document the site.

Standard Checklist

Name of Riparian-Wetland Area: ____

Date: ________ **Area/Segment ID:** _______________________ **Miles:** ______________________

ID Team Observers: ____

HYDROLOGIC (circle one)

Yes /No/ N/A 1) Floodplain inundated in "relatively frequent" events (1-3 years)

Yes/ No /N/A 2) Active/stable beaver dams

Yes/ No /N/A 3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)

Yes/ No/ N/A 4) Riparian zone is widening or has achieved potential extent

Yes /No /N/A 5) Upland watershed not contributing to riparian degradation

VEGETATIVE (circle one)

Yes /No/ N/A 6) Diverse age-class distribution (recruitment for maintenance/recovery)

Yes/ No/ N/A 7) Diverse composition of vegetation (for maintenance/recovery)

Yes /No/ N/A 8) Species present indicate maintenance of riparian soil moisture characteristics

Yes /No/ N/A 9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events

Yes/ No/ N/A 10) Riparian plants exhibit high vigor

Yes /No /N/A 11) Adequate vegetative cover present to protect banks and dissipate energy during high flows

Yes/ No/ N/A 12) Plant communities in the riparian area are an adequate source of coarse and/or large woody debris

SOILS-EROSION DEPOSITION (circle one)

Yes/ No /N/A 13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody debris) adequate to dissipate energy

Yes /No /N/A 14) Point bars are revegetating
Yes /No/ N/A 15) Lateral stream movement is associated with natural sinuosity
Yes/ No /N/A 16) System is vertically stable
Yes /No /N/A 17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks:
____
____
____
____
____
____
____

Summary Determination Functional Rating:
Proper Functioning Condition ____________________
Functional – At Risk ____________________
Nonfunctional ____________________
Unknown ____________________

Trend for Functional – At Risk:
Upward ____________________
Downward ____________________
Not Apparent ____________________

Are factors contributing to unacceptable conditions outside BLM's control or management?
Yes ____________________
No ____________________

If yes, what are those factors?
____ Flow regulations
____ Mining activities
____ Upstream channel conditions
____ Channelization
____ Road encroachment
____ Oil Field water discharge
____ Augmented flows
____ Other (specify) ______________________________________

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Appendix AA: Greater Sage-Grouse and Sagebrush Habitats: Monitoring, Monitoring Framework, Disturbance Caps, Effects Analysis Process, Mitigation, Mitigation Measures, Conservation Action Resources, Required Design Features, and Applying Lek Buffers

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Appendix AA: Greater Sage-Grouse and Sagebrush Habitats:

Monitoring, Monitoring Framework, Disturbance Caps, Effects Analysis Process, Mitigation, Mitigation Measures, Conservation Action Resources, Required Design Features, and Applying Lek Buffers

A. Monitoring of Sage-grouse and Sagebrush Habitats

A.1 Background

On March 5, 2010 the 12-Month Findings for Petitions to List the Greater Sage-grouse (*Centrocercus urophasianus*) as Threatened or Endangered were posted as a Federal Register notice (75 FR 13910 14014). This notice stated:

> "…the information collected by BLM could not be used to make broad generalizations about the status of rangelands and management actions. There was a lack of consistency across the range in how questions were interpreted and answered for the data call, which limited our ability to use the results to understand habitat conditions for sage-grouse on BLM lands. For example, one question asked about the number of acres of land within sage-grouse habitat that was meeting rangeland health standards. Field offices in more than three States conducted the rangeland health assessments, and reported landscape conditions at different scales (Sell 2009, pers. comm.). In addition, the BLM data call reported information at a different scale than was used for their landscape mapping (District or project level versus national scale) (Buckner 2009b, pers. comm.)."

Given the degree of uncertainty associated with managing natural resources, adaptive management approaches that include rigorous monitoring protocols to support them are essential if conservation goals are to be realized (Walters 1986, Burgman et al. 2005, Stankey et al. 2005, Turner 2005, Lyons et al. 2008). Recent efforts to develop range-wide policy and conservation measures for sage-grouse have emphasized the importance of improving monitoring efforts on both sage-grouse distribution and population trends, as well as the habitat they depend on (Wambolt et al. 2002, Connelly et al. 2003, Stiver et al. 2006, Reese and Boyer 2007, Connelly et al. 2011). Connelly et al. (2003) and Stiver et al. (2010) identified the need to assess and monitor sage-grouse habitats based on habitat characterization that should follow habitat selection processes identified by Johnson (1980). These processes identify four selection orders: (1) rangewide, (2) physical and geographic range of populations, (3) physical and geographic range within home ranges, and (4) physical and geographic areas within seasonal ranges to meet the life requisites of sage-grouse. These four habitat selection orders each have unique habitat indicators that should be assessed and monitored to properly evaluate sage-grouse habitats and relate those habitat indicators back to sage-grouse populations.

Monitoring tied to Resource Management Plan (RMP) decisions has two parts: (1) implementation monitoring (implementation of decisions, waivers, modifications, etc.), and (2) effectiveness monitoring. Through effectiveness monitoring, BLM can answer questions about how our decisions and actions impact habitat. Understanding the effectiveness and validating results of RMPs and management decisions is an important part of BLM measuring its performance under the Government Performance Results Act. For example, riparian condition is a primary measure for RMP effectiveness (see WO IM 2010-101). Monitoring that is applicable for evaluating management effectiveness can also be used to address a number of other critical habitat variables (e.g., location, condition, habitat conversion, size of patches, number of patches, species composition, connectivity and linkage, etc.). Ideally, monitoring attributes of sage-grouse habitat and sage-grouse populations will allow linking real or potential habitat changes (from both natural events and management actions) to vital rates of sage-grouse populations (Stiver et al. 2006, Naugle and Walker 2007). These conclusions will enable managers to identify indicators associated with population change across large landscapes and to ameliorate negative effects with appropriate conservation actions (Burgman et al. 2005, Turner 2005).

A.2 Sage-Grouse Habitat Assessment Framework

In August 2010, the Sage-Grouse Habitat Assessment Framework (HAF): Multi-scale Habitat Assessment Tool was completed (Stiver et al. 2010). The HAF provides policy makers, resource managers, and natural resource specialists a comprehensive framework for sage grouse specific habitat assessments within sagebrush ecosystems. Assessment and monitoring of sage-grouse habitat is scale dependent. The HAF provides consistent indicators, metric descriptions, and habitat suitability characteristics for each of these scales specific to sage-grouse. It also provides consistent terminology so that biologists, other resource specialists, and managers from a wide range of agencies can address sage-grouse habitats. Monitoring inappropriate indicators for various scales can result in monitoring results that cannot correctly evaluate sage-grouse habitats and can misinform management of the effectiveness of land use plan decisions and activity level management actions.

A.3 BLM Assessment, Inventory, and Monitoring Strategy

The BLM Assessment, Inventory, and Monitoring (AIM) Strategy (Toevs et al. 2011) was completed in 2011 (BLM IB 2012-080) and describes a vision for integrated, cross-program assessment, inventory, and monitoring of resources at multiple scales of management. Following the AIM Strategy, the BLM is modernizing its resource monitoring approach to more efficiently and effectively meet local, regional, and national resource information needs. The AIM Strategy provides a process for the BLM to collect quantitative information on the condition, trend, amount, location, and spatial pattern of natural resources on the public lands. Each AIM-Monitoring survey, at any scale of inquiry (from the plot level to westwide deployments), uses a set of core indicators, standardized field methods, remote sensing, and a statistically valid study design to provide nationally consistent and scientifically defensible information to determine condition (e.g., rangeland health) and trend on public lands.

The National-scale deployment of AIM (i.e. Landscape Monitoring Framework [LMF]) commenced in 2011 with the collection of 1,000 plots of field-collected monitoring data across the Western U.S. The LMF will add approximately 1,000 new plots per year on non-forested public rangeland West-wide, plus an additional 1,000 plots per year in greater sage-grouse priority habitats. These national core data sets will be integrated with locally collected, project level, core data and remote sensing data to determine the condition and trend of sage-grouse habitats and the effectiveness of BLM management actions. This will be used to address threats and stressors, restore priority habitats, and maintain spatial connectivity at multiple scales of inquiry (from plots to landscapes and regions). Further, these multi-scale data will provide information to determine long-term achievement of planning goals and objectives, analyze cumulative effects, and serve as the basis for adaptive management actions. A critical element of greater sage-grouse monitoring will be the production of an annual public report summarizing the broad scale condition and trend of priority habitats. Analysis of condition and trend reports will adaptively feed back into the monitoring process and will be refined as necessary. Additional site- or population-scale monitoring or habitat assessments, specific to greater sage-grouse needs, may be implemented when necessary through the Sage-Grouse HAF to answer specific local management questions or refine adaptive management needs that are not addressed by the AIM-Monitoring core indicators.

A.4 Adaptive Management

When a hard trigger is hit in a Biologically Significant Unit (BSU) within a Priority Area for Conservation (PAC) that has multiple BSUs, including those that cross state lines, the Western Association of Fish and Wildlife Agencies (WAFWA) Management Zone Greater Sage-Grouse Conservation Team will convene to determine the causal factor, put project level responses in place, as appropriate and discuss further appropriate actions to be applied. The team will also investigate the status of the hard triggers in other BSUs within the PAC and will invoke the appropriate plane response.

A.5 Implementation

The standardization of monitoring methods and implementation of a defensible monitoring approach (within and across jurisdictions) is vital if BLM and other conservation partners are to use the resulting information to guide implementation of conservation activities. Monitoring strategies for sage-grouse habitat and populations must be collaborative, as habitat occurs across jurisdictional boundaries (52% BLM, 31% private, 8% USFS, 5% state, 4% tribal and other Federal; 75 FR 13910), and because state fish and wildlife agencies have primary responsibility for population level management of wildlife, including population monitoring. Population efforts therefore will continue to be conducted in partnership with state fish and wildlife agencies. The BLM will coordinate our multiple internal, habitat-based protocols among jurisdictions, as feasible, to provide large scale data sets to understand trends in sagebrush ecosystems.

Implementation policy directing use of the HAF, and the HAF in conjunction with AIM-Monitoring in addition to other guidance in the BLM National Greater Sage-Grouse Land Use Planning Strategy will be necessary to provide a framework for consistent approaches to sage-grouse habitat condition and trend monitoring across planning units and jurisdictions. This implementation policy will be developed by BLM in cooperation with our conservation partners.

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B. The Greater Sage-Grouse Monitoring Framework

Developed by the Interagency GRSG Disturbance and Monitoring Subteam May 30, 2014

B.1 INTRODUCTION

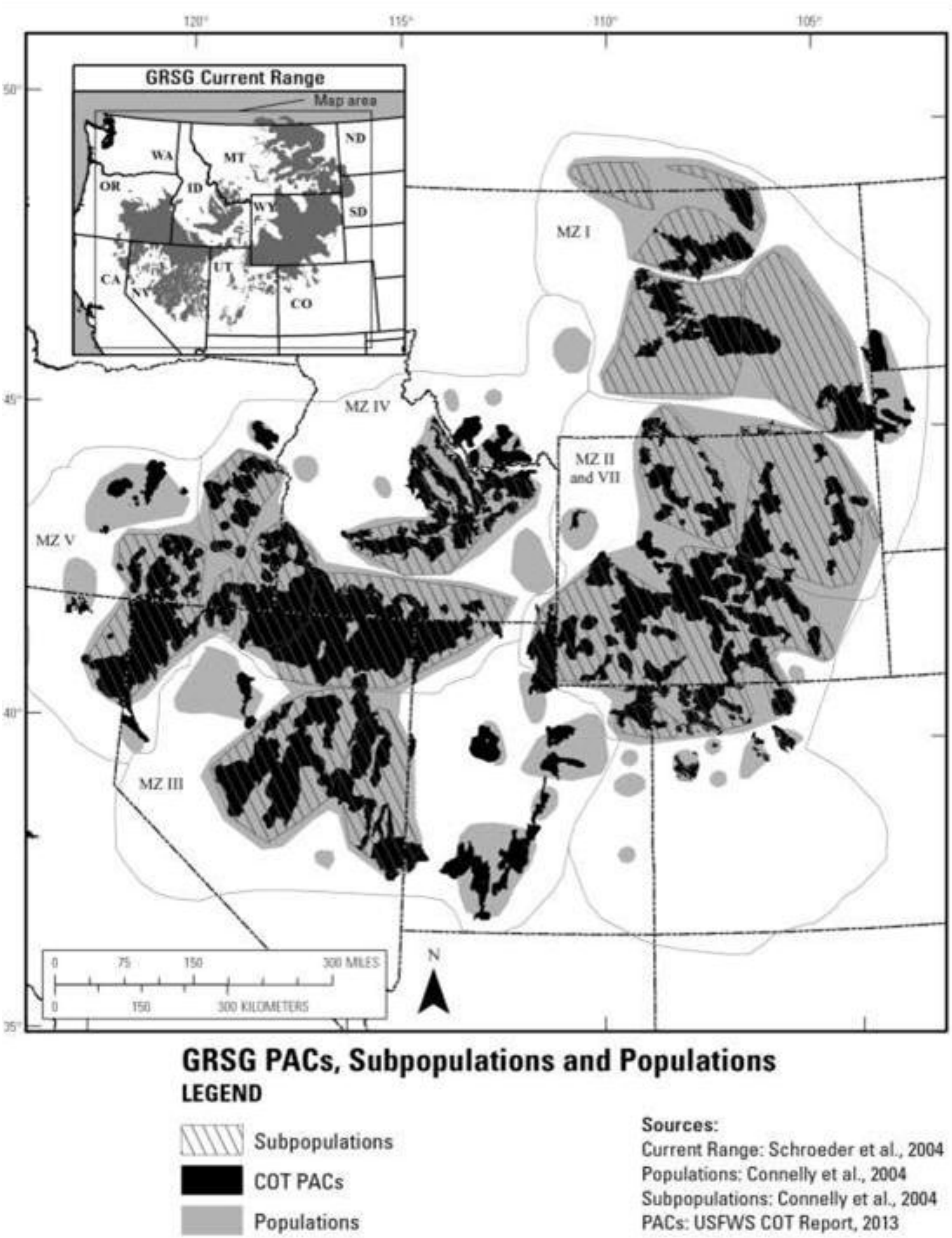
The purpose of this U.S. Bureau of Land Management (BLM) and U.S. Forest Service (USFS) Greater Sage-Grouse Monitoring Framework (hereafter, monitoring framework) is to describe the methods to monitor habitats and evaluate the implementation and effectiveness of the BLM's national planning strategy (attachment to BLM Instruction Memorandum 2012-044), the BLM resource management plans (RMPs), and the USFS's land management plans (LMPs) to conserve the species and its habitat. The regulations for the BLM (43 CFR 1610.4-9) and the USFS (36 CFR part 209, published July 1, 2010) require that land use plans establish intervals and standards, as appropriate, for monitoring and evaluations based on the sensitivity of the resource to the decisions involved. Therefore, the BLM and the USFS will use the methods described herein to collect monitoring data and to evaluate implementation and effectiveness of the Greater Sage-Grouse (GRSG) (hereafter, sage-grouse) planning strategy and the conservation measures contained in their respective land use plans (LUPs). A monitoring plan specific to the Environmental Impact Statement, land use plan, or field office will be developed after the Record of Decision is signed. For a summary of the frequency of reporting, see Attachment A, An Overview of Monitoring Commitments. Adaptive management will be informed by data collected at any and all scales.

To ensure that the BLM and the USFS are able to make consistent assessments about sage-grouse habitats across the range of the species, this framework lays out the methodology—at multiple scales—for monitoring of implementation and disturbance and for evaluating the effectiveness of BLM and USFS actions to conserve the species and its habitat. Monitoring efforts will include data for measurable quantitative indicators of sagebrush availability, anthropogenic disturbance levels, and sagebrush conditions. Implementation monitoring results will allow the BLM and the USFS to evaluate the extent that decisions from their LUPs to conserve sage-grouse and their habitat have been implemented. State fish and wildlife agencies will collect population monitoring information, which will be incorporated into effectiveness monitoring as it is made available.

This multiscale monitoring approach is necessary, as sage-grouse are a landscape species and conservation is scale-dependent to the extent that conservation actions are implemented within seasonal habitats to benefit populations. The four orders of habitat selection (Johnson 1980) used in this monitoring framework are described by Connelly et al. (2003) and were applied specifically to the scales of sage-grouse habitat selection by Stiver et al. (in press) as first order (broad scale), second order (mid scale), third order (fine scale), and fourth order (site scale). Habitat selection and habitat use by sage-grouse occur at multiple scales and are driven by multiple environmental and behavioral factors. Managing and monitoring sage-grouse habitats are complicated by the differences in habitat selection across the range and habitat use by individual birds within a given season. Therefore, the tendency to look at a single indicator of habitat suitability or only one scale limits managers' ability to identify the threats to sage-grouse and to respond at the appropriate scale. For descriptions of these habitat suitability indicators for each scale, see “Sage-Grouse Habitat Assessment Framework: Multiscale Habitat Assessment Tool” (HAF; Stiver et al. 2015 in press).

Monitoring methods and indicators in this monitoring framework are derived from the current peer-reviewed science. Rangewide, best available datasets for broad- and mid-scale monitoring will be acquired. If these existing datasets are not readily available or are inadequate, but they are necessary to inform the indicators of sagebrush availability, anthropogenic disturbance levels, and sagebrush conditions, the BLM and the USFS will strive to develop datasets or obtain information to fill these data gaps. Datasets that are not readily available to inform the fine- and site-scale indicators will be developed. These data will be used to generate monitoring reports at the appropriate and applicable geographic scales, boundaries, and analysis units: across the range of sage-grouse as defined by Schroeder et al. (2004), and clipped by Western Association of Fish and Wildlife Agencies (WAFWA) Management Zone (MZ) (Stiver et al. 2006) boundaries and other areas as appropriate for size (e.g., populations based on Connelly et al. 2004). (Figure B-1, Map of Greater Sage-Grouse range, populations, subpopulations, and Priority Areas for Conservation as of 2013.) This broad- and mid-scale monitoring data and analysis will provide context for RMP/LMP areas; states; GRSG Priority Habitat, General Habitat, and other sage-grouse designated management areas; and Priority Areas for Conservation (PACs), as defined in “Greater Sage-grouse (*Centrocercus urophasianus*) Conservation Objectives: Final Report” (Conservation Objectives Team [COT] 2013). Hereafter, all of these areas will be referred to as “sage-grouse areas.”

Figure B-1: Map of Greater Sage-Grouse range, populations, subpopulations, and Priority Areas for Conservation as of 2013.



This monitoring framework is divided into two sections. The broad- and mid-scale methods, described in B.2, provide a consistent approach across the range of the species to monitor implementation decisions and actions, mid-scale habitat attributes (e.g., sagebrush availability and habitat degradation), and population changes to determine the effectiveness of the planning strategy and management decisions. (Table B-1, Indicators for monitoring implementation of the national planning strategy, RMP/LMP decisions, sage-grouse habitat, and sage-grouse populations at the broad and mid scales.) For sage-grouse habitat at the fine and site scales, described in B.3, this monitoring framework describes a consistent approach (e.g., indicators and methods) for monitoring sage-grouse seasonal habitats. Funding, support, and dedicated personnel for broad- and mid-scale monitoring will be renewed annually through the normal budget process. For an overview of BLM and USFS multiscale monitoring commitments, see Attachment A.

Table B-1: Indicators for monitoring implementation of the national planning strategy, RMP/LMP decisions, sage-grouse habitat, and sage-grouse populations at the broad and mid scales.

	Implementation	Habitat		Population (State Wildlife Agencies)
Geographic Scales		Availability	Degradation	Demographics
Broad Scale: From the range of sage-grouse to WAFWA Management Zones	BLM/USFS National Planning Strategy goal and objectives	Distribution and amount of sagebrush within the range	Distribution and amount of energy, mining and infrastructure facilities	WAFWA Management Zone population trend
Mid-scale: From WAFWA Management Zone to populations; PACs	RMP/LMP decisions	Mid-scale habitat indicators (HAF; Table 2 herein, e.g., percent of sagebrush per unit area)	Distribution and amount of energy, mining, and infrastructure facilities (Table 2 herein)	Individual population trend

B.2 BROAD and MID-SCALES

First-order habitat selection, the broad scale, describes the physical or geographical range of a species. The first-order habitat of the sage-grouse is defined by populations of sage-grouse associated with sagebrush landscapes, based on Schroeder et al. 2004, and Connelly et al. 2004, and on population or habitat surveys since 2004. An intermediate scale between the broad and mid scales was delineated by WAFWA from floristic provinces within which similar environmental factors influence vegetation communities. This scale is referred to as the WAFWA Sage-Grouse Management Zones (MZs). Although no indicators are specific to this scale, these MZs are biologically meaningful as reporting units.

Second-order habitat selection, the mid-scale, includes sage-grouse populations and PACs. The second order includes at least 40 discrete populations and subpopulations (Connelly et al. 2004). Populations range in area from 150 to 60,000 mi2 and are nested within MZs. PACs range from 20 to 20,400 mi2 and are nested within population areas.

Other mid-scale landscape indicators, such as patch size and number, patch connectivity, linkage areas, and landscape matrix and edge effects (Stiver et al. in press) will also be assessed. The methods used to calculate these metrics will be derived from existing literature (Knick et al. 2011, Leu and Hanser 2011, Knick and Hanser 2011).

B.2.1 Implementation (Decision) Monitoring

Implementation monitoring is the process of tracking and documenting the implementation (or the progress toward implementation) of RMP/LMP decisions. The BLM and the USFS will monitor implementation of project-level and/or site-specific actions and authorizations, with their associated conditions of approval/stipulations for sage-grouse, spatially (as appropriate) within Priority Habitat, General Habitat, and other sage-grouse designated management areas, at a minimum, for the planning area. These actions and authorizations, as well as progress toward completing and implementing activity-level plans, will be monitored consistently across all planning units and will be reported to BLM and USFS headquarters annually, with a summary report every 5 years, for the planning area. A national-level GRSG Land Use Plan Decision Monitoring and Reporting Tool is being developed to describe how the BLM and the USFS will consistently and systematically monitor and report implementation-level activity plans and implementation actions for all plans within the range of sage-grouse. A description of this tool for collection and reporting of tabular and spatially explicit data will be included in the Record of Decision or approved plan. The BLM and the USFS will provide data that can be integrated with other conservation efforts conducted by state and federal partners.

B.2.2 Habitat Monitoring

The U.S. Fish and Wildlife Service (USFWS), in its 2010 listing decision for the sage-grouse, identified 18 threats contributing to the destruction, modification, or curtailment of sage-grouse habitat or range (75 FR 13910 2010). The BLM and the USFS will, therefore, monitor the relative extent of these threats that remove sagebrush, both spatially and temporally, on all lands within an analysis area, and will report on amount, pattern, and condition at the appropriate and applicable geographic scales and boundaries. These 18 threats have been aggregated into three broad- and mid-scale measures to account for whether the threat predominantly removes sagebrush or degrades habitat. (Table B-2, Relationship between the 18 threats and the three habitat disturbance measures for monitoring.) The three measures are:

Measure 1: Sagebrush Availability (percent of sagebrush per unit area)
Measure 2: Habitat Degradation (percent of human activity per unit area)
Measure 3: Energy and Mining Density (facilities and locations per unit area)

These three habitat disturbance measures will evaluate disturbance on all lands, regardless of land ownership. The direct area of influence will be assessed with the goal of accounting for actual removal of sagebrush on which sage-grouse depend (Connelly et al. 2000) and for habitat degradation as a surrogate for human activity. Measure 1 (sagebrush availability) examines where disturbances have removed plant communities that support sagebrush (or have broadly removed sagebrush from the landscape). Measure 1, therefore, monitors the change in sagebrush availability—or, specifically, where and how much of the sagebrush community is available within the range of sage-grouse. The sagebrush community is defined as the ecological systems that have the capability of supporting sagebrush vegetation and seasonal sage-grouse habitats within the range of sage-grouse (B.2.2.1, Sagebrush Availability). Measure 2 (B.2.2.2, Habitat Degradation Monitoring) and Measure 3 (B.2.2.3., Energy and Mining Density) focus on where habitat degradation is occurring by using the footprint/area of direct disturbance and the number of facilities at the mid scale to identify the relative amount of degradation per geographic area of interest and in areas that have the capability of supporting sagebrush and seasonal sage-grouse use. Measure 2 (habitat degradation) not only quantifies footprint/area of direct disturbance but also establishes a surrogate for those threats most likely to have ongoing activity. Because energy development and mining activities are typically the most intensive activities in sagebrush habitat, Measure 3 (the density of active energy development, production, and mining sites) will help identify areas of particular concern for such factors as noise, dust, traffic, etc. that degrade sage-grouse habitat..

Table B-2: Relationship between the 18 threats and the three habitat disturbance measures for monitoring.

Note: Data availability may preclude specific analysis of individual layers. See the detailed methodology for more information.

USFWS Listing Decision Threat	Sagebrush Availability	Habitat Degradation	Energy and Mining Density
Agriculture	X		
Urbanization	X		
Wildfire	X		
Conifer encroachment	X		
Treatments	X		
Invasive Species	X		
Energy (oil and gas wells and development facilities)		X	X
Energy (coal mines)		X	X
Energy (wind towers)		X	X
Energy (solar fields)		X	X
Energy (geothermal)		X	X
Mining (active locatable, leasable, and salable developments)		X	X
Infrastructure (roads)		X	
Infrastructure (railroads)		X	
Infrastructure (power lines)		X	
Infrastructure (communication towers)		X	
Infrastructure (other vertical structures)		X	
Other developed rights of ways		X	

The methods to monitor disturbance found herein differ slightly from methods used in Manier et al. 2013, which provided a baseline environmental report (BER) of datasets of disturbance across jurisdictions. One difference is that, for some threats, the BER data were for federal lands only. In addition, threats were assessed individually, using different assumptions from those in this monitoring framework about how to quantify the location and magnitude of threats. The methodology herein builds on the BER methodology and identifies datasets and procedures to use the best available data across the range of the sage-grouse and to formulate a consistent approach to quantify impact of the threats through time. This methodology also describes an approach to combine the threats and calculate each of the three habitat disturbance measures.

B.2.2.1 Sagebrush Availability (Measure 1)

Sage-grouse populations have been found to be more resilient where a percentage of the landscape is maintained in sagebrush (Knick and Connelly 2011), which will be determined by sagebrush availability. Measure 1 has been divided into two submeasures to describe sagebrush availability on the landscape:

Measure 1a: the current amount of sagebrush on the geographic area of interest, and
Measure 1b: the amount of sagebrush on the geographic area of interest compared with the amount of sagebrush the landscape of interest could ecologically support.

Measure 1a (the current amount of sagebrush on the landscape) will be calculated using this formula: [the existing updated sagebrush layer] divided by [the geographic area of interest]. The appropriate geographic areas of interest for sagebrush availability include the species' range, WAFWA MZs, populations, and PACs. In some cases these sage-grouse areas will need to be aggregated to provide an estimate of sagebrush availability with an acceptable level of accuracy.

Measure 1b (the amount of sagebrush for context within the geographic area of interest) will be calculated using this formula: [existing sagebrush divided by [pre-EuroAmerican settlement geographic extent of lands that could have supported sagebrush]. This measure will provide information to set the context for a given geographic area of interest during evaluations of monitoring data. The information could also be used to inform management options for restoration or mitigation and to inform effectiveness monitoring.

The sagebrush base layer for Measure 1 will be based on geospatial vegetation data adjusted for the threats listed in Table B-2. The following subsections of this monitoring framework describe the methodology for determining both the current availability of sagebrush on the landscape and the context of the amount of sagebrush on the landscape at the broad and mid scales.

B.2.2.1.1 Establishing the Sagebrush Base Layer

The current geographic extent of sagebrush vegetation within the rangewide distribution of sage-grouse populations will be ascertained using the most recent version of the Existing Vegetation Type (EVT) layer in LANDFIRE (2013). LANDFIRE EVT was selected to serve as the sagebrush base layer for five reasons: 1) it is the only nationally consistent vegetation layer that has been updated multiple times since 2001; 2) the ecological systems classification within LANDFIRE EVT includes multiple sagebrush type classes that, when aggregated, provide a more accurate (compared with individual classes) and seamless sagebrush base layer across jurisdictional boundaries; 3) LANDFIRE performed a rigorous accuracy assessment from which to derive the rangewide uncertainty of the sagebrush base layer; 4) LANDFIRE is consistently used in several recent analyses of sagebrush habitats (Knick et al. 2011, Leu and Hanser 2011, Knick and Hanser 2011); and 5) LANDFIRE EVT can be compared against the geographic extent of lands that are believed to have had the capability of supporting sagebrush vegetation pre-EuroAmerican settlement [LANDFIRE Biophysical Setting (BpS)]. This fifth reason provides a reference point for understanding how much sagebrush currently remains in a defined geographic area of interest compared with how much sagebrush existed historically (Measure 1b). Therefore, the BLM and the USFS have determined that LANDFIRE provides the best available data at broad and mid scales to serve as a sagebrush base layer for monitoring changes in the geographic extent of sagebrush. The BLM and the USFS, in addition to aggregating the sagebrush types into the sagebrush base layer, will aggregate the accuracy assessment reports from LANDFIRE to document the cumulative accuracy for the sagebrush base layer. The BLM—through its Assessment, Inventory, and Monitoring (AIM) program and, specifically, the BLM's landscape monitoring framework (Taylor et al. 2014)—will provide field data to the LANDFIRE program to support continuous quality improvements of the LANDFIRE EVT layer. The sagebrush layer based on LANDFIRE EVT will allow for the mid-scale estimation of the existing percent of sagebrush across a variety of reporting units. This sagebrush base layer will be adjusted by changes in land cover and successful restoration for future calculations of sagebrush availability (Measures 1a and 1b).

This layer will also be used to determine the trend in other landscape indicators, such as patch size and number, patch connectivity, linkage areas, and landscape matrix and edge effects (Stiver et al. in press). In the future, changes in sagebrush availability, generated annually, will be included in the sagebrush base layer. The landscape metrics will be recalculated to examine changes in pattern and abundance of sagebrush at the various geographic boundaries. This information will be included in effectiveness monitoring (B.2.4, Effectiveness Monitoring).

Within the USFS and the BLM, forest-wide and field office–wide existing vegetation classification mapping and inventories are available that provide a much finer level of data than what is provided through LANDFIRE. Where available, these finer-scale products will be useful for additional and complementary mid-scale indicators and local-scale analyses (B.3, Fine and Site Scales). The fact that these products are not available everywhere limits their utility for monitoring at the broad and mid scale, where consistency of data products is necessary across broader geographies.

Data Sources for Establishing and Monitoring Sagebrush Availability

There were three criteria for selecting the datasets for establishing and monitoring the change in sagebrush availability (Measure 1):

- Nationally consistent dataset available across the range
- Known level of confidence or accuracy in the dataset
- Continual maintenance of dataset and known update interval

Datasets meeting these criteria are listed in Table B-3, Datasets for establishing and monitoring changes in sagebrush availability.

LANDFIRE Existing Vegetation Type (EVT) Version 1.2

LANDFIRE EVT represents existing vegetation types on the landscape derived from remote sensing data. Initial mapping was conducted using imagery collected in approximately 2001.

Since the initial mapping there have been two update efforts: version 1.1 represents changes before 2008, and version 1.2 reflects changes on the landscape before 2010. Version 1.2 will be used as the starting point to develop the sagebrush base layer.

Sage-grouse subject matter experts determined which of the ecological systems from the LANDFIRE EVT to use in the sagebrush base layer by identifying the ecological systems that have the capability of supporting sagebrush vegetation and that could provide suitable seasonal habitat for the sage-grouse. (Table B-4, Ecological systems in BpS and EVT capable of supporting sagebrush vegetation and capable of providing suitable seasonal habitat for Greater Sage-Grouse.) Two additional vegetation types that are not ecological systems were added to the EVT: *Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance and *Quercus gambelii* Shrubland Alliance. These alliances have species composition directly related to the Rocky Mountain Lower Montane-Foothill Shrubland ecological system and the Rocky Mountain Gambel Oak-Mixed Montane Shrubland ecological system, both of which are ecological systems in LANDFIRE BpS. In LANDFIRE EVT, however, in some map zones, the Rocky Mountain Lower Montane-Foothill Shrubland ecological system and the Rocky Mountain Gambel Oak-Mixed Montane Shrubland ecological system were named *Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance and *Quercus gambelii* Shrubland Alliance, respectively.

Table B-3: Datasets for establishing and monitoring changes in sagebrush availability.

Dataset	Source	Update Interval	Most Recent Version Year	Use
BioPhysical Setting v1.1	LANDFIRE	Static	2008	Denominator for sagebrush availability
Existing Vegetation Type v1.2	LANDFIRE	Static	2010	Numerator for sagebrush availability
Cropland Data Layer	National Agricultural Statistics Service	Annual	2012	Agricultural updates; removes existing sagebrush from numerator of sagebrush availability
National Land Cover Dataset Percent Imperviousness	Multi-Resolution Land Characteristics Consortium (MRLC)	5-Year	2011 (next available in 2016)	Urban area updates; removes existing sagebrush from numerator of sagebrush availability
Fire Perimeters	GeoMac	Annual	2013	< 1,000-acre fire updates; removes existing sagebrush from numerator of sagebrush availability
Burn Severity	Monitoring Trends in Burn Severity	Annual	2012 (2-year delay in data availability)	> 1,000-acre fire updates; removes existing sagebrush from numerator of sagebrush availability except for unburned sagebrush islands

Table B-4: Ecological systems in BpS and EVT capable of supporting sagebrush vegetation and capable of providing suitable seasonal habitat for Greater Sage-Grouse.

Ecological System	Sagebrush Vegetation that the Ecological System has the Capability of Producing

Colorado Plateau Mixed Low Sagebrush Shrubland	*Artemisia arbuscula* ssp. *longiloba* *Artemisia bigelovii* *Artemisia nova* *Artemisia frigida* *Artemisia tridentata* ssp. *wyomingensis*
Columbia Plateau Low Sagebrush Steppe	*Artemisia arbuscula* *Artemisia arbuscula* ssp. *longiloba* *Artemisia nova*
Columbia Plateau Scabland Shrubland	*Artemisia rigida*
Columbia Plateau Steppe and Grassland	*Artemisia* spp.
Great Basin Xeric Mixed Sagebrush Shrubland	*Artemisia arbuscula* ssp. *longicaulis* *Artemisia arbuscula* ssp. *longiloba* *Artemisia nova* *Artemisia tridentata* ssp. *wyomingensis*
Inter-Mountain Basins Big Sagebrush Shrubland	*Artemisia tridentata* ssp. *tridentata* *Artemisia tridentata* ssp. *xericensis* *Artemisia tridentata* ssp. *vaseyana* *Artemisia tridentata* ssp. *wyomingensis*
Inter-Mountain Basins Big Sagebrush Steppe	*Artemisia cana* ssp. *cana* *Artemisia tridentata* ssp. *tridentata* *Artemisia tridentata* ssp. *xericensis* *Artemisia tridentata* ssp. *wyomingensis* *Artemisia tripartita* ssp. *tripartita* *Artemisia frigida*
Inter-Mountain Basins Curl-Leaf Mountain Mahogany Woodland and Shrubland	*Artemisia tridentata* ssp. *vaseyana* *Artemisia arbuscula* *Artemisia tridentata*
Inter-Mountain Basins Mixed Salt Desert Scrub	*Artemisia tridentata* ssp. *wyomingensis* *Artemisia spinescens*
Inter-Mountain Basins Montane Sagebrush Steppe	*Artemisia tridentata* ssp. *vaseyana* *Artemisia tridentata* ssp. *wyomingensis* *Artemisia nova* *Artemisia arbuscula* *Artemisia tridentata* ssp. *spiciformis*
Inter-Mountain Basins Semi-Desert Shrub-Steppe	*Artemisia tridentata* *Artemisia bigelovii* *Artemisia tridentata* ssp. *wyomingensis*
Northwestern Great Plains Mixed Grass Prairie	*Artemisia cana* ssp. *cana* *Artemisia tridentata* ssp. *vaseyana* *Artemisia frigida*
Northwestern Great Plains Shrubland	*Artemisia cana* ssp. *cana* *Artemisia tridentata* ssp. *tridentata* *Artemisia tridentata* ssp. *wyomingensis*
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	*Artemisia tridentata*
Rocky Mountain Lower Montane-Foothill Shrubland	*Artemisia nova* *Artemisia tridentata* *Artemisia frigida*
Western Great Plains Floodplain Systems	*Artemisia cana* ssp. *cana*
Western Great Plains Sand Prairie	*Artemisia cana* ssp. *cana*

Wyoming Basins Dwarf Sagebrush Shrubland and Steppe	*Artemisia arbuscula* ssp. *longiloba* *Artemisia nova* *Artemisia tridentata* ssp. *wyomingensis* *Artemisia tripartita* ssp. *rupicola*
Artemisia tridentata ssp. *vaseyana* Shrubland Alliance (EVT only)	*Artemisia tridentata* ssp. *vaseyana*
Quercus gambelii Shrubland Alliance (EVT only)	*Artemisia tridentata*

Accuracy and Appropriate Use of LANDFIRE Datasets

Because of concerns over the thematic accuracy of individual classes mapped by LANDFIRE, all ecological systems listed in Table B-4 will be merged into one value that represents the sagebrush base layer. With all ecological systems aggregated, the combined accuracy of the sagebrush base layer (EVT) will be much greater than if all categories were treated separately.

LANDFIRE performed the original accuracy assessment of its EVT product on a map zone basis. There are 20 LANDFIRE map zones that cover the historical range of sage-grouse as defined by Schroeder (2004). (See Attachment B, User and Producer Accuracies for Aggregated Ecological Systems within LANDFIRE Map Zones.) The aggregated sagebrush base layer for monitoring had user accuracies ranging from 57.1% to 85.7% and producer accuracies ranging from 56.7% to 100%.

LANDFIRE EVT data are not designed to be used at a local level. In reports of the percent sagebrush statistic for the various reporting units (Measure 1a), the uncertainty of the percent sagebrush will increase as the size of the reporting unit gets smaller. LANDFIRE data should never be used at the 30m pixel level (900m2 resolution of raster data) for any reporting. The smallest geographic extent for using the data to determine percent sagebrush is at the PAC level; for the smallest PACs, the initial percent sagebrush estimate will have greater uncertainties compared with the much larger PACs.

Agricultural Adjustments for the Sagebrush Base Layer

The dataset for the geographic extent of agricultural lands will come from the National Agricultural Statistics Service (NASS) Cropland Data Layer (CDL) (http://www.nass.usda.gov/research/Cropland/Release/index.htm). CDL data are generated annually, with estimated producer accuracies for "large area row crops ranging from the mid 80% to mid-90%," depending on the state (http://www.nass.usda.gov/research/Cropland/sarsfaqs2.htm#Section3_18.0). Specific information on accuracy may be found on the NASS metadata website (http://www.nass.usda.gov/research/Cropland/metadata/meta.htm). CDL provided the only dataset that matches the three criteria (nationally consistent, known level of accuracy, and periodically updated) for use in this monitoring framework and represents the best available agricultural lands mapping product.

The CDL data contain both agricultural classes and nonagricultural classes. For this effort, and in the baseline environmental report (Manier et al. 2013), nonagricultural classes were removed from the original dataset. The excluded classes are:

> Barren (65 & 131), Deciduous Forest (141), Developed/High Intensity (124), Developed/Low Intensity (122), Developed/Med Intensity (123), Developed/Open Space (121), Evergreen Forest (142), Grassland Herbaceous (171), Herbaceous Wetlands (195), Mixed Forest (143), Open Water (83 & 111), Other Hay/Non Alfalfa (37), Pasture/Hay (181), Pasture/Grass (62), Perennial Ice/Snow (112), Shrubland (64 & 152), Woody Wetlands (190).

The rule set for adjusting the sagebrush base layer for agricultural lands (and for updating the base layer for agricultural lands in the future) is that once an area is classified as agriculture in any year of the CDL, those pixels will remain out of the sagebrush base layer even if a new version of the CDL classifies that pixel as one of the nonagricultural classes listed above. The assumption is that even though individual pixels may be classified as a nonagricultural class in any given year, the pixel has not necessarily been restored to a natural sagebrush community that would be included in Table B-4. A further assumption is that once an area has moved into agricultural use, it is unlikely that the area would be restored to sagebrush. Should that occur, however, the method and criteria for adding pixels back into the sagebrush base layer would follow those found in the sagebrush restoration monitoring section of this monitoring framework B.2.2.1.2, Monitoring Sagebrush Availability).

Urban Adjustments for the Sagebrush Base Layer

The National Land Cover Database (NLCD) (Fry et al. 2011) includes a percent imperviousness dataset that was selected as the best available dataset to be used for urban adjustments and monitoring. These data are generated on a 5-year cycle and are specifically designed to support monitoring efforts. Other datasets were evaluated and lacked the spatial specificity that was captured in the NLCD product. Any new impervious pixel in NLCD will be removed from the sagebrush base layer through the monitoring process. Although the impervious surface layer includes a number of impervious pixels outside of urban areas, this is acceptable for the adjustment and monitoring for two reasons. First, an evaluation of national urban area datasets did not reveal a layer that could be confidently used in conjunction with the NLCD product to screen impervious pixels outside of urban zones. This is because unincorporated urban areas were not being included, thus leaving large chunks of urban pixels unaccounted for in this rule set. Second, experimentation with setting a threshold on the percent imperviousness layer that would isolate rural features proved to be unsuccessful. No combination of values could be identified that would result in the consistent ability to limit impervious pixels outside urban areas. Therefore, to ensure consistency in the monitoring estimates, all impervious pixels will be used.

Fire Adjustments for the Sagebrush Base Layer

Two datasets were selected for performing fire adjustments and updates: GeoMac fire perimeters and Monitoring Trends in Burn Severity (MTBS). An existing data standard in the

BLM requires that all fires of more than 10 acres are to be reported to GeoMac; therefore, there will be many small fires of less than 10 acres that will not be accounted for in the adjustment and monitoring attributable to fire. Using fire perimeters from GeoMac, all sagebrush pixels falling within the perimeter of fires less than 1,000 acres will be used to adjust and monitor the sagebrush base layer.

For fires greater than 1,000 acres, MTBS was selected as a means to account for unburned sagebrush islands during the update process of the sagebrush base layer. The MTBS program (http://www.mtbs.gov) is an ongoing, multiyear project to map fire severity and fire perimeters consistently across the United States. One of the burn severity classes within MTBS is an unburned to low-severity class. This burn severity class will be used to represent unburned islands of sagebrush within the fire perimeter for the sagebrush base layer. Areas within the other severity classes within the fire perimeter will be removed from the base sagebrush layer during the update process. Not all wildfires, however, have the same impacts on the recovery of sagebrush habitat, depending largely on soil moisture and temperature regimes. For example, cooler, moister sagebrush habitat has a higher potential for recovery or, if needed, restoration than does the warmer, dryer sagebrush habitat. These cooler, moister areas will likely be detected as sagebrush in future updates to LANDFIRE.

Conifer Encroachment Adjustment for the Sagebrush Base Layer

Conifer encroachment into sagebrush vegetation reduces the spatial extent of sage-grouse habitat (Davies et al. 2011, Baruch-Mordo et al. 2013). Conifer species that show propensity for encroaching into sagebrush vegetation resulting in sage-grouse habitat loss include various juniper species, such as Utah juniper (*Juniperus osteosperma*), western juniper (*Juniperus occidentalis*), Rocky Mountain juniper (*Juniperus scopulorum*), pinyon species, including singleleaf pinyon (*Pinus monophylla*) and pinyon pine (*Pinus edulis*), ponderosa pine (*Pinus ponderosa*), lodgepole pine (*Pinus contorta*), and Douglas fir (*Pseudotsuga menziesii*) (Gruell et al. 1986, Grove et al. 2005, Davies et al. 2011).

A rule set for conifer encroachment was developed to adjust the sagebrush base layer. To capture the geographic extent of sagebrush that is likely to experience conifer encroachment, ecological systems within LANDFIRE EVT version 1.2 (NatureServe 2011) were identified if they had the capability of supporting both the conifer species (listed above) and sagebrush vegetation. Those ecological systems were deemed to be the plant communities with conifers most likely to encroach into sagebrush vegetation. (Table B-5, Ecological systems with conifers most likely to encroach into sagebrush vegetation.) Sagebrush vegetation was defined as including sagebrush species or subspecies that provide habitat for the Greater Sage-Grouse and that are included in the HAF. (See Attachment C, Sagebrush Species and Subspecies Included in the Selection Criteria for Building the EVT and BpS Layers.) An adjacency analysis was conducted to identify all sagebrush pixels that were directly adjacent to these conifer ecological systems, and these pixels were removed from the sagebrush base layer.

Table B-5: Ecological Systems with Conifers Most Likely to Encroach into Sagebrush Vegetation

EVT Ecological Systems	Coniferous Species and Sagebrush Vegetation

	that the Ecological System has the Capability to Produce
Colorado Plateau Pinyon-Juniper Woodland	*Pinus edulis* *Juniperus osteosperma* *Artemisia tridentata* *Artemisia arbuscula* *Artemisia nova* *Artemisia tridentata* ssp. *tridentata* *Artemisia tridentata* ssp. *wyomingensis* *Artemisia tridentata* ssp. *vaseyana* *Artemisia bigelovii* *Artemisia pygmaea*
Columbia Plateau Western Juniper Woodland and Savanna	*Juniperus occidentalis* *Pinus ponderosa* *Artemisia tridentata* *Artemisia arbuscula* *Artemisia rigida* *Artemisia tridentata* ssp. *vaseyana*
East Cascades Oak-Ponderosa Pine Forest and Woodland	*Pinus ponderosa* *Pseudotsuga menziesii* *Artemisia tridentata* *Artemisia nova*
Great Basin Pinyon-Juniper Woodland	*Pinus monophylla* *Juniperus osteosperma* *Artemisia arbuscula* *Artemisia nova* *Artemisia tridentata* *Artemisia tridentata* ssp. *vaseyana*
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	*Pinus ponderosa* *Artemisia tridentata* *Artemisia arbuscula* *Artemisia tridentata* ssp. *vaseyana*
Rocky Mountain Foothill Limber Pine-Juniper Woodland	*Juniperus osteosperma* *Juniperus scopulorum* *Artemisia nova* *Artemisia tridentata*
Rocky Mountain Poor-Site Lodgepole Pine Forest	*Pinus contorta* *Pseudotsuga menziesii* *Pinus ponderosa* *Artemisia tridentata*
Southern Rocky Mountain Pinyon-Juniper Woodland	*Pinus edulis* *Juniperus monosperma* *Artemisia bigelovii* *Artemisia tridentata* *Artemisia tridentata* ssp. *wyomingensis* *Artemisia tridentata* ssp.*vaseyana*
Southern Rocky Mountain Ponderosa Pine Woodland	*Pinus ponderosa* *Pseudotsuga menziesii* *Pinus edulis* *Pinus contorta*

	Juniperus spp. *Artemisia nova* *Artemisia tridentata* *Artemisia arbuscula* *Artemisia tridentata* ssp. *vaseyana*

Invasive Annual Grasses Adjustments for the Sagebrush Base Layer

There are no invasive species datasets from 2010 to the present (beyond the LANDFIRE data) that meet the three criteria (nationally consistent, known level of accuracy, and periodically updated) for use in the determination of the sagebrush base layer. For a description of how invasive species land cover will be incorporated in the sagebrush base layer in the future, see B.2.2.1.2., Monitoring Sagebrush Availability.

Sagebrush Restoration Adjustments for the Sagebrush Base Layer

There are no datasets from 2010 to the present that could provide additions to the sagebrush base layer from restoration treatments that meet the three criteria (nationally consistent, known level of accuracy, and periodically updated); therefore, no adjustments were made to the sagebrush base layer calculated from the LANDFIRE EVT (version 1.2) attributable to restoration activities since 2010. Successful restoration treatments before 2010 are assumed to have been captured in the LANDFIRE refresh.

B.2.2.1.2 Monitoring Sagebrush Availability

Sagebrush Availability Updates

Sagebrush availability will be updated annually by incorporating changes to the sagebrush base layer attributable to agriculture, urbanization, and wildfire. The monitoring schedule for the existing sagebrush base layer updates is as follows:

> ***Base 2010 Existing Sagebrush Layer*** = [Sagebrush EVT] minus [2006 Imperviousness Layer] minus [2009 and 2010 CDL] minus [2009/10 GeoMac Fires that are less than 1,000 acres] minus [2009/10 MTBS Fires that are greater than 1,000 acres, excluding unburned sagebrush islands within the perimeter] minus [Conifer Encroachment Layer]
>
> ***2012 Existing Sagebrush Update*** = [2010 Existing Sagebrush Base Layer] minus [2011 Imperviousness Layer] minus [2011 and 2012 CDL] minus [2011/12 GeoMac Fires < 1,000 acres] minus [2011/12 MTBS Fires that are greater than 1,000 acres, excluding unburned sagebrush islands within the perimeter]
>
> ***Monitoring Existing Sagebrush post 2012*** = [Previous Existing Sagebrush Update Layer] minus [Imperviousness Layer (if new data are available)] minus [Next 2 years of CDL] minus [Next 2 years of GeoMac Fires < 1,000 acres] minus [Next 2 years of MTBS Fires that are greater than 1,000 acres, excluding unburned sagebrush islands within the perimeter] plus [restoration/monitoring data provided by the field]

Monitoring Sagebrush Restoration

Restoration after fire, after agricultural conversion, after seedings of introduced grasses, or after treatments of pinyon pine and/or juniper are examples of updates to the sagebrush base layer that can add sagebrush vegetation back into sagebrush availability in the landscape. When restoration has been determined to be successful through rangewide, consistent, interagency fine- and site-scale monitoring, the polygonal data will be used to add sagebrush pixels back into the broad- and mid-scale sagebrush base layer.

Measure1b: Context for Monitoring the Amount of Sagebrush in a Geographic Area of Interest
Measure 1b describes the amount of sagebrush on the landscape of interest compared with the amount of sagebrush the landscape of interest could ecologically support. Areas with the potential to support sagebrush were derived from the BpS data layer that describes sagebrush pre-EuroAmerican settlement (v1.2 of LANDFIRE).

The identification and spatial locations of natural plant communities (vegetation) that are believed to have existed on the landscape (BpS) were constructed based on an approximation of the historical (pre-EuroAmerican settlement) disturbance regime and how the historical disturbance regime operated on the current biophysical environment. BpS is composed of map units that are based on NatureServe (2011) terrestrial ecological systems classification.

The ecological systems within BpS used for this monitoring framework are those ecological systems that are capable of supporting sagebrush vegetation and of providing seasonal habitat for sage-grouse (Table B-4). Ecological systems selected included sagebrush species or subspecies that are included in the HAF and listed in Attachment C.

The BpS layer does not have an associated accuracy assessment, given the lack of any reference data. Visual inspection of the BpS data, however, reveals inconsistencies in the labeling of pixels among LANDFIRE map zones. The reason for these inconsistencies is that the rule sets used to map a given ecological system will vary among map zones based on different physical, biological, disturbance, and atmospheric regimes of the region. These variances can result in artificial edges in the map. Metrics will be calculated, however, at broad spatial scales using BpS potential vegetation type, not small groupings or individual pixels. Therefore, the magnitude of these observable errors in the BpS layer will be minor compared with the size of the reporting units. Since BpS will be used to identify broad landscape patterns of dominant vegetation, these inconsistencies will have only a minor impact on the percent sagebrush availability calculation. As with the LANDFIRE EVT, LANDFIRE BpS data are not designed to be used at a local level. LANDFIRE data should never be used at the 30m pixel level for reporting.

In conclusion, sagebrush availability data will be used to inform effectiveness monitoring and initiate adaptive management actions as necessary. The 2010 estimate of sagebrush availability will serve as the base year, and an updated estimate for 2012 will be reported in 2014 after all datasets become available. The 2012 estimate will capture changes attributable to wildfire, agriculture, and urban development. Subsequent updates will always include new fire and agricultural data and new urban data when available. Restoration data that meet the criteria for adding sagebrush areas back into the sagebrush base layer will be factored in as data allow. Given data availability, there will be a 2-year lag (approximately) between when the estimate is generated and when the data used for the estimate become available (e.g., the 2014 sagebrush availability will be included in the 2016 estimate).

Future Plans

Geospatial data used to generate the sagebrush base layer will be available through the BLM's EGIS web portal and geospatial gateway or through the authoritative data source. Legacy datasets will be preserved so that trends may be calculated. Additionally, accuracy assessment data for all source datasets will be provided on the portal either spatially, where applicable, or through the metadata. Accuracy assessment information was deemed vital to help users understand the limitation of the sagebrush estimates; it will be summarized spatially by map zone and will be included in the portal.

LANDFIRE plans to begin a remapping effort in 2015. This remapping has the potential to improve the overall quality of data products greatly, primarily through the use of higher-quality remote sensing datasets. Additionally, the BLM and the Multi-Resolution Land Characteristics Consortium (MRLC) are working to improve the accuracy of vegetation map products for broad- and mid-scale analyses through the Grass/Shrub mapping effort. The Grass/Shrub mapping effort applies the Wyoming multiscale sagebrush habitat methodology (Homer et al. 2009) to depict spatially the fractional percent cover estimates for five components rangewide and West-wide. These five components are percent cover of sagebrush vegetation, percent bare ground, percent herbaceous vegetation (grass and forbs combined), annual vegetation, and percent shrubs. A benefit of the design of these fractional cover maps is that they facilitate monitoring "within" class variation (e.g., examination of declining trend in sagebrush cover for individual pixels). This "within" class variation can serve as one indicator of sagebrush quality that cannot be derived from LANDFIRE's EVT information. The Grass/Shrub mapping effort is not a substitute for fine-scale monitoring but will leverage fine-scale data to support the validation of the mapping products. An evaluation will be conducted to determine if either dataset is of great enough quality to warrant replacing the existing sagebrush layers. At the earliest, this evaluation will occur in 2018 or 2019, depending on data availability.

B.2.2.2 Habitat Degradation Monitoring (Measure 2)

The measure of habitat degradation will be calculated by combining the footprints of threats identified in Table B-2. The footprint is defined as the direct area of influence of "active" energy and infrastructure; it is used as a surrogate for human activity. Although these analyses will try to summarize results at the aforementioned meaningful geographic areas of interest, some may be too small to report the metrics appropriately and may be combined (smaller populations, PACs within a population, etc.). Data sources for each threat are found in Table B-6, Geospatial data sources for habitat degradation. Specific assumptions (inclusion criteria for data, width/area assumptions for point and line features, etc.) and methodology for each threat, and the combined measure, are detailed below. All datasets will be updated annually to monitor broad- and mid-scale year-to-year changes and to calculate trends in habitat degradation to inform adaptive management. A 5-year summary report will be provided to the USFWS.

B.2.2.2.1 Habitat Degradation Datasets and Assumptions

Energy (oil and gas wells and development facilities)
This dataset will compile information from three oil and gas databases: the proprietary IHS Enerdeq database, the BLM Automated Fluid Minerals Support System (AFMSS) database, and the proprietary Platts (a McGraw-Hill Financial Company) GIS Custom Data (hereafter, Platts) database of power plants. Point data from wells active within the last 10 years from IHS and

producing wells from AFMSS will be considered as a 5-acre (2.0ha) direct area of influence centered on the well point, as recommended by the BLM WO-300 (Minerals and Realty Management). Plugged and abandoned wells will be removed if the date of well abandonment was before the first day of the reporting year (i.e., for the 2015 reporting year, a well must have been plugged and abandoned by 12/31/2014 to be removed). Platts oil and gas power plants data (subset to operational power plants) will also be included as a 5-acre (2.0ha) direct area of influence.

> ***Additional Measure: Reclaimed Energy-related Degradation*** This dataset will include those wells that have been plugged and abandoned. This measure thereby attempts to measure energy-related degradation that has been reclaimed but not necessarily fully restored to sage-grouse habitat. This measure will establish a baseline by using wells that have been plugged and abandoned within the last 10 years from the IHS and AFMSS datasets. Time lags for lek attendance in response to infrastructure have been documented to be delayed 2–10 years from energy development activities (Harju et al. 2010). Reclamation actions may require 2 or more years from the Final Abandonment Notice. Sagebrush seedling establishment may take 6 or more years from the point of seeding, depending on such variables as annual precipitation, annual temperature, and soil type and depth (Pyke 2011). This 10-year period is conservative and assumes some level of habitat improvement 10 years after plugging. Research by Hemstrom et al. (2002), however, proposes an even longer period—more than 100 years—for recovery of sagebrush habitats, even with active restoration approaches. Direct area of influence will be considered 3 acres (1.2ha) (J. Perry, personal communication, February 12, 2014). This additional layer/measure could be used at the broad and mid scale to identify areas where sagebrush habitat and/or potential sagebrush habitat is likely still degraded. This layer/measure could also be used where further investigation at the fine or site scale would be warranted to: 1) quantify the level of reclamation already conducted, and 2) evaluate the amount of restoration still required for sagebrush habitat recovery. At a particular level (e.g., population, PACs), these areas and the reclamation efforts/success could be used to inform reclamation standards associated with future developments. Once these areas have transitioned from reclamation standards to meeting restoration standards, they can be added back into the sagebrush availability layer using the same methodology as described for adding restoration treatment areas lost to wildfire and agriculture conversion (Monitoring Sagebrush Restoration in B.2.2.1.2, Monitoring Sagebrush Availability). This dataset will be updated annually from the IHS dataset.

Energy (coal mines)

Currently, there is no comprehensive dataset available that identifies the footprint of active coal mining across all jurisdictions. Therefore, point and polygon datasets will be used each year to identify coal mining locations. Data sources will be identified and evaluated annually and will include at a minimum: BLM coal lease polygons, U.S. Energy Information Administration mine occurrence points, U.S. Office of Surface Mining Reclamation and Enforcement coal mining permit polygons (as available), and U.S. Geological Survey (USGS) Mineral Resources Data System mine occurrence points. These data will inform where active coal mining may be occurring. Additionally, coal power plant data from Platts power plants database (subset to operational power plants) will be included. Aerial imagery will then be used to digitize manually the active coal mining and coal power plants surface disturbance in or near these known occurrence areas. While the date of aerial imagery varies by scale, the most current data available from Esri and/or Google will be used to locate (generally at 1:50,000 and below) and digitize (generally at 1:10,000 and below) active coal mine and power plant direct area of influence. Coal mine location data source and imagery date will be documented for each digitized coal polygon at the time of creation. Subsurface facility locations (polygon or point location as available) will also be collected if available, included in density calculations, and added to the active surface activity layer as appropriate (if an actual direct area of influence can be located).

Energy (wind towers)

This dataset will be a subset of the Federal Aviation Administration (FAA) Digital Obstacles point file. Points where "Type_" = "WINDMILL" will be included. Direct area of influence of these point features will be measured by converting to a polygon dataset as a direct area of influence of 3 acres (1.2ha) centered on each tower point. See the BLM's "Wind Energy Development Programmatic Environmental Impact Statement" (BLM 2005). Additionally, Platts power plants database will be used for transformer stations associated with wind energy sites (subset to operational power plants), also with a 3-acre (1.2ha) direct area of influence.

Energy (solar energy facilities)

This dataset will include solar plants as compiled with the Platts power plants database (subset to operational power plants). This database includes an attribute that indicates the operational capacity of each solar power plant. Total capacity at the power plant was based on ratings of the in-service unit(s), in megawatts. Direct area of influence polygons will be centered over each point feature representing 7.3ac (3.0ha) per megawatt of the stated operational capacity, per the report of the National Renewable Energy Laboratory (NREL), "Land-Use Requirements for Solar Power Plants in the United States" (Ong et al. 2013).

Energy (geothermal energy facilities)

This dataset will include geothermal wells in existence or under construction as compiled with the IHS wells database and power plants as compiled with the Platts database (subset to operational power plants). Direct area of influence of these point features will be measured by converting to a polygon dataset of 3 acres (1.2ha) centered on each well or power plant point.

Mining (active developments; locatable, leasable, saleable)

This dataset will include active locatable mining locations as compiled with the proprietary InfoMine database. Aerial imagery will then be used to digitize manually the active mining surface disturbance in or near these known occurrence areas. While the date of aerial imagery varies by scale, the most current data available from Esri and/or Google will be used to locate (generally at 1:50,000 and below) and digitize (generally at 1:10,000 and below) active mine direct area of influence. Mine location data source and imagery date will be documented for each digitized polygon at the time of creation. Currently, there are no known compressive databases available for leasable or saleable mining sites beyond coal mines. Other data sources will be evaluated and used as they are identified or as they become available. Point data may be converted to polygons to represent direct area of influence unless actual surface disturbance is available.

Infrastructure (roads)

This dataset will be compiled from the proprietary Esri StreetMap Premium for ArcGIS. Dataset features that will be used are: Interstate Highways, Major Roads, and Surface Streets to capture most paved and "crowned and ditched" roads while not including "two-track" and 4-wheel-drive routes. These minor roads, while not included in the broad- and mid-scale monitoring, may support a volume of traffic that can have deleterious effects on sage-grouse leks. It may be appropriate to consider the frequency and type of use of roads in a NEPA analysis for a proposed project. This fine- and site-scale analysis will require more site-specific data than is identified in this monitoring framework. The direct area of influence for roads will be represented by 240.2ft, 84.0ft, and 40.7ft (73.2m, 25.6m, and 12.4m) total widths centered on the line feature for Interstate Highways, Major Roads, and Surface Streets, respectively (Knick et al. 2011). The most current dataset will be used for each monitoring update. Note: This is a related but different dataset than what was used in BER (Manier et al. 2013). Individual BLM/USFS planning units may use different road layers for fine- and site-scale monitoring.

Infrastructure (railroads)

This dataset will be a compilation from the Federal Railroad Administration Rail Lines of the USA dataset. Non-abandoned rail lines will be used; abandoned rail lines will not be used. The direct are of influence for railroads will be represented by a 30.8ft (9.4m) total width (Knick et al. 2011) centered on the non-abandoned railroad line feature.

Infrastructure (power lines)

This line dataset will be derived from the proprietary Platts transmission lines database. Linear features in the dataset attributed as "buried" will be removed from the disturbance calculation. Only "In Service" lines will be used; "Proposed" lines will not be used. Direct area of influence will be determined by the kV designation: 1–199 kV (100ft/30.5m), 200–399 kV (150ft/45.7m), 400–699 kV (200ft/61.0m), and 700-or greater kV (250ft/76.2m) based on average right-of-way and structure widths, according to BLM WO-300 (Minerals and Realty Management).

Infrastructure (communication towers)

This point dataset will be compiled from the Federal Communications Commission (FCC) communication towers point file; all duplicate points will be removed. It will be converted to a polygon dataset by using a direct area of influence of 2.5 acres (1.0ha) centered on each communication tower point (Knick et al. 2011).

Infrastructure (other vertical structures)

This point dataset will be compiled from the FAA's Digital Obstacles point file. Points where "Type_" = "WINDMILL" will be removed. Duplicate points from the FCC communication towers point file will be removed. Remaining features will be converted to a polygon dataset using a direct area of influence of 2.5 acres (1.0ha) centered on each vertical structure point (Knick et al. 2011).

Other developed rights-of-ways

Currently, no additional data sources for other rights-of-way have been identified; roads, power lines, railroads, pipelines, and other known linear features are represented in the categories described above. The newly purchased IHS data do contain pipeline information; however, this database does not currently distinguish between above-ground and underground pipelines. If additional features representing human activities are identified, they will be added to monitoring reports using similar assumptions to those used with the threats described above.

B.2.2.2.2 Habitat Degradation Threat Combination and Calculation

The threats targeted for measuring human activity (Table B-2) will be converted to direct area of influence polygons as described for each threat above. These threat polygon layers will be combined and features dissolved to create one overall polygon layer representing footprints of active human activity in the range of sage-grouse. Individual datasets, however, will be preserved to indicate which types of threats may be contributing to overall habitat degradation.

This measure has been divided into three submeasures to describe habitat degradation on the landscape. Percentages will be calculated as follows:

1) Measure 2a. Footprint by geographic area of interest: Divide area of the active/direct footprint by the total area of the geographic area of interest (% disturbance in geographic area of interest).
2) Measure 2b. Active/direct footprint by historical sagebrush potential: Divide area of the active footprint that coincides with areas with historical sagebrush potential (BpS calculation from habitat availability) within a given geographic area of interest by the total area with sagebrush potential within the geographic area of interest (% disturbance on potential historical sagebrush in geographic area of interest).
3) Measure 2c. Active/direct footprint by current sagebrush: Divide area of the active footprint that coincides with areas of existing sagebrush (EVT calculation from habitat availability) within a given geographic area of interest by the total area that is current sagebrush within the geographic area of interest (% disturbance on current sagebrush in geographic area of interest))

B.2.2.3 Energy and Mining Density (Measure 3)

The measure of density of energy and mining will be calculated by combining the locations of energy and mining threats identified in Table B-2. This measure will provide an estimate of the intensity of human activity or the intensity of habitat degradation. The number of energy facilities and mining locations will be summed and divided by the area of meaningful geographic areas of interest to calculate density of these activities. Data sources for each threat are found in Table B-6. Specific assumptions (inclusion criteria for data, width/area assumptions for point and line features, etc.) and methodology for each threat, and the combined measure, are detailed below. All datasets will be updated annually to monitor broad- and mid-scale year-to-year changes and 5-year (or longer) trends in habitat degradation.

Table B-6: Geospatial Data Sources for Habitat Degradation (Measure 2)

Geospatial data sources for habitat degradation (Measure 2)				
Degradation Type	**Subcategory**	**Data Source**	**Direct Area of Influence**	**Area Source**
Energy (oil & gas)	Wells	IHS; BLM (AFMSS)	5.0ac (2.0ha)	BLM WO-300
	Power Plants	Platts (power plants)	5.0ac (2.0ha)	BLM WO-300
Energy (coal)	Mines	BLM; USFS; Office of Surface Mining Reclamation and Enforcement; USGS Mineral Resources Data System	Polygon area (digitized)	Esri/ Google Imagery
	Power Plants	Platts (power plants)	Polygon area (digitized)	Esri Imagery
Energy (wind)	Wind Turbines	Federal Aviation Administration	3.0ac (1.2ha)	BLM WO-300
	Power Plants	Platts (power plants)	3.0ac (1.2ha)	BLM WO-300
Energy (solar)	Fields/Power Plants	Platts (power plants)	7.3ac (3.0ha)/MW	NREL
Energy (geothermal)	Wells	IHS	3.0ac (1.2ha)	BLM WO-300
	Power Plants	Platts (power plants)	Polygon area (digitized)	Esri Imagery
Mining	Locatable Developments	InfoMine	Polygon area (digitized)	Esri Imagery
Infrastructure (roads)	Surface Streets (Minor Roads)	Esri StreetMap Premium	40.7ft (12.4m)	USGS
	Major Roads	Esri StreetMap Premium	84.0ft (25.6m)	USGS
	Interstate Highways	Esri StreetMap Premium	240.2ft (73.2m)	USGS
Infrastructure (railroads)	Active Lines	Federal Railroad Administration	30.8ft (9.4m)	USGS
Infrastructure (power lines)	1-199kV Lines	Platts (transmission lines)	100ft (30.5m)	BLM WO-300
	200-399 kV Lines	Platts (transmission lines)	150ft (45.7m)	BLM WO-300
	400-699kV Lines	Platts (transmission lines)	200ft (61.0m)	BLM WO-300
	700+kV Lines	Platts (transmission lines)	250ft (76.2m)	BLM WO-300
Infrastructure (communication)	Towers	Federal Communications Commission	2.5ac (1.0ha)	BLM WO-300

B.2.2.3.1 Energy and Mining Density Datasets and Assumptions

Energy (oil and gas wells and development facilities)
(See Section B.2.2.2, Habitat Degradation Monitoring.)

Energy (coal mines)
(See Section B.2.2.2, Habitat Degradation Monitoring.)

Energy (wind energy facilities)
(See Section B.2.2.2, Habitat Degradation Monitoring.)

Energy (solar energy facilities)
(See Section B.2.2.2, Habitat Degradation Monitoring.)

Energy (geothermal energy facilities)
(See Section B.2.2.2, Habitat Degradation Monitoring.)

Mining (active developments; locatable, leasable, saleable)
(See Section B.2.2.2, Habitat Degradation Monitoring.

B.2.2.3.2 Energy and Mining Density Threat Combination and Calculation

Datasets for energy and mining will be collected in two primary forms: point locations (e.g., wells) and polygon areas (e.g., surface coal mining). The following rule set will be used to calculate density for meaningful geographic areas of interest including standard grids and per polygon:

1. Point locations will be preserved; no additional points will be removed beyond the methodology described above. Energy facilities in close proximity (an oil well close to a wind tower) will be retained.
2. Polygons will not be merged, or features further dissolved. Thus, overlapping facilities will be retained, such that each individual threat will be a separate polygon data input for the density calculation.
3. The analysis unit (polygon or 640-acre section in a grid) will be the basis for counting the number of mining or energy facilities per unit area. Within the analysis unit, all point features will be summed, and any individual polygons will be counted as one (e.g., a coal mine will be counted as one facility within population). Where polygon features overlap multiple units (polygons or pixels), the facility will be counted as one in each unit where the polygon occurs (e.g., a polygon crossing multiple 640-acre sections would be counted as one in each 640-acre section for a density per 640-acre- section calculation).
4. In methodologies with different-sized units (e.g., MZs, populations, etc.) raw facility counts will be converted to densities by dividing the raw facility counts by the total area of the unit. Typically this will be measured as facilities per 640 acres.

5. For uniform grids, raw facility counts will be reported. Typically this number will also be converted to facilities per 640 acres.
6. Reporting may include summaries beyond the simple ones above. Zonal statistics may be used to smooth smaller grids to help display and convey information about areas within meaningful geographic areas of interest that have high levels of energy and/or mining activity.
7. Additional statistics for each defined unit may also include adjusting the area to include only the area with the historical potential for sagebrush (BpS) or areas currently sagebrush (EVT).

Individual datasets and threat combination datasets for habitat degradation will be available through the BLM's EGIS web portal and geospatial gateway. Legacy datasets will be preserved so that trends may be calculated.

B.2.3 Population (Demographics) Monitoring

State wildlife management agencies are responsible for monitoring sage-grouse populations within their respective states. WAFWA will coordinate this collection of annual population data by state agencies. These data will be made available to the BLM according to the terms of the forthcoming Greater Sage-Grouse Population Monitoring Memorandum of Understanding (MOU) (2014) between WAFWA and the BLM. The MOU outlines a process, timeline, and responsibilities for regular data sharing of sage-grouse population and/or habitat information for the purposes of implementing sage-grouse LUPs/amendments and subsequent effectiveness monitoring. Population areas were refined from the "Greater Sage-grouse (*Centrocercus urophasianus*) Conservation Objectives: Final Report" (COT 2013) by individual state wildlife agencies to create a consistent naming nomenclature for future data analyses. These population data will be used for analysis at the applicable scale to supplement habitat effectiveness monitoring of management actions and to inform the adaptive management responses.

B.2.4 Effectiveness Monitoring

Effectiveness monitoring will provide the data needed to evaluate BLM and USFS actions toward reaching the objective of the national planning strategy (BLM IM 2012-044)—to conserve sage-grouse populations and their habitat—and the objectives for the land use planning area. Effectiveness monitoring methods described here will encompass multiple larger scales, from areas as large as the WAFWA MZ to the scale of this LUP. Effectiveness data used for these larger-scale evaluations will include all lands in the area of interest, regardless of surface ownership/management, and will help inform where finer-scale evaluations are needed, such as population areas smaller than an LUP or PACs within an LUP (described in Section B.3, Fine and Site Scales). Data will also include the trend of disturbance within these areas of interest to inform the need to initiate adaptive management responses as described in the land use plan.

Effectiveness monitoring reported for these larger areas provides the context to conduct effectiveness monitoring at finer scales. This approach also helps focus scarce resources to areas experiencing habitat loss, degradation, or population declines, without excluding the possibility of concurrent, finer-scale evaluations as needed where habitat or population anomalies have been identified through some other means.

To determine the effectiveness of the sage-grouse national planning strategy, the BLM and the USFS will evaluate the answers to the following questions and prepare a broad- and mid-scale effectiveness report:

1. Sagebrush Availability and Condition:
    a. What is the amount of sagebrush availability and the change in the amount and condition of sagebrush?
    b. What is the existing amount of sagebrush on the landscape and the change in the amount relative to the pre-EuroAmerican historical distribution of sagebrush (BpS)?
    c. What is the trend and condition of the indicators describing sagebrush characteristics important to sage-grouse?
2. Habitat Degradation and Intensity of Activities:
    a. What is the amount of habitat degradation and the change in that amount?
    b. What is the intensity of activities and the change in the intensity?
    c. What is the amount of reclaimed energy-related degradation and the change in the amount?
3. What is the population estimation of sage-grouse and the change in the population estimation?
4. How are the BLM and the USFS contributing to changes in the amount of sagebrush?
5. How are the BLM and the USFS contributing to disturbance?

The compilation of broad- and mid-scale data (and population trends as available) into an effectiveness monitoring report will occur on a 5-year reporting schedule (see Attachment A), which may be accelerated to respond to critical emerging issues (in consultation with the USFWS and state wildlife agencies). In addition, effectiveness monitoring results will be used to identify emerging issues and research needs and inform the BLM and the USFS adaptive management strategy (see the adaptive management section of this Environmental Impact Statement).

To determine the effectiveness of the sage-grouse objectives of the land use plan, the BLM and the USFS will evaluate the answers to the following questions and prepare a plan effectiveness report:

1. Is this plan meeting the sage-grouse habitat objectives?
2. Are sage-grouse areas within the LUP meeting, or making progress toward meeting, land health standards, including the Special Status Species/wildlife habitat standard?
3. Is the plan meeting the disturbance objective(s) within sage-grouse areas?
4. Are the sage-grouse populations within this plan boundary and within the sage-grouse areas increasing, stable, or declining?

The effectiveness monitoring report for this LUP will occur on a 5-year reporting schedule (see Attachment A) or more often if habitat or population anomalies indicate the need for an evaluation to facilitate adaptive management or respond to critical emerging issues. Data will be made available through the BLM's EGIS web portal and the geospatial gateway.

Methods

At the broad and mid scales (PACs and above) the BLM and the USFS will summarize the vegetation, disturbance, and (when available) population data. Although the analysis will try to summarize results for PACs within each sage-grouse population, some populations may be too small to report the metrics appropriately and may need to be combined to provide an estimate with an acceptable level of accuracy. Otherwise, they will be flagged for more intensive monitoring by the appropriate landowner or agency. The BLM and the USFS will then analyze monitoring data to detect the trend in the amount of sagebrush; the condition of the vegetation in the sage-grouse areas (MacKinnon et al. 2011); the trend in the amount of disturbance; the change in disturbed areas owing to successful restoration; and the amount of new disturbance the BLM and/or the USFS has permitted. These data could be supplemented with population data (when available) to inform an understanding of the correlation between habitat and PACs within a population. This overall effectiveness evaluation must consider the lag effect response of populations to habitat changes (Garton et al. 2011).

Calculating Question 1, National Planning Strategy Effectiveness: The amount of sagebrush available in the large area of interest will use the information from Measure 1a (B.2.2.1, Sagebrush Availability) and calculate the change from the 2012 baseline to the end date of the reporting period. To calculate the change in the amount of sagebrush on the landscape to compare with the historical areas with potential to support sagebrush, the information from Measure 1b (B.2.2.1, Sagebrush Availability) will be used. To calculate the trend in the condition of sagebrush at the mid scale, three sources of data will be used: the BLM's Grass/Shrub mapping effort (Future Plans in Section B.2.2.1, Sagebrush Availability); the results from the calculation of the landscape indicators, such as patch size (described below); and the BLM's Landscape Monitoring Framework (LMF) and sage-grouse intensification effort (also described below). The LMF and sage-grouse intensification effort data are collected in a statistical sampling framework that allows calculation of indicator values at multiple scales.

Beyond the importance of sagebrush availability to sage-grouse, the mix of sagebrush patches on the landscape at the broad and mid scale provides the life requisite of space for sage-grouse dispersal needs (see the HAF). The configuration of sagebrush habitat patches and the land cover or land use between the habitat patches at the broad and mid scales also defines suitability. There are three significant habitat indicators that influence habitat use, dispersal, and movement across populations: the size and number of habitat patches, the connectivity of habitat patches (linkage areas), and habitat fragmentation (scope of unsuitable and non-habitats between habitat patches). The most appropriate commercial software to measure patch dynamics, connectivity, and fragmentation at the broad and mid scales will be used, along with the same data layers derived for sagebrush availability.

The BLM initiated the LMF in 2011 in cooperation with the Natural Resources Conservation Service (NRCS). The objective of the LMF effort is to provide unbiased estimates of vegetation and soil condition and trend using a statistically balanced sample design across BLM lands. Recognizing that sage-grouse populations are more resilient where the sagebrush plant community has certain characteristics unique to a particular life stage of sage-grouse (Knick and

Connelly 2011, Stiver et al. *in press*), a group of sage-grouse habitat and sagebrush plant community subject matter experts identified those vegetation indicators collected at LMF sampling points that inform sage-grouse habitat needs. The experts represented the Agricultural Research Service, BLM, NRCS, USFWS, WAFWA, state wildlife agencies, and academia. The common indicators identified include: species composition, foliar cover, height of the tallest sagebrush and herbaceous plant, intercanopy gap, percent of invasive species, sagebrush shape, and bare ground. To increase the precision of estimates of sagebrush conditions within the range of sage-grouse, additional plot locations in occupied sage-grouse habitat (Sage-Grouse Intensification) were added in 2013. The common indicators are also collected on sampling locations in the NRCS National Resources Inventory Rangeland Resource Assessment (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?&cid=stelprdb1041620).

The sage-grouse intensification baseline data will be collected over a 5-year period, and an annual sage-grouse intensification report will be prepared describing the status of the indicators. Beginning in year 6, the annual status report will be accompanied with a trend report, which will be available on an annual basis thereafter, contingent on continuation of the current monitoring budget. This information, in combination with the Grass/Shrub mapping information, the mid-scale habitat suitability indicator measures, and the sagebrush availability information will be used to answer Question 1 of the National Planning Strategy Effectiveness Report.

Calculating Question 2, National Planning Strategy Effectiveness: Evaluations of the amount of habitat degradation and the intensity of the activities in the area of interest will use the information from Measure 2 (Section B.2.2.2, Habitat Degradation Monitoring) and Measure 3 (Section B.2.2.3, Energy and Mining Density). The field office will collect data on the amount of reclaimed energy-related degradation on plugged and abandoned and oil/gas well sites. The data are expected to demonstrate that the reclaimed sites have yet to meet the habitat restoration objectives for sage-grouse habitat. This information, in combination with the amount of habitat degradation, will be used to answer Question 2 of the National Planning Strategy Effectiveness Report.

Calculating Question 3, National Planning Strategy Effectiveness: The change in sage-grouse estimated populations will be calculated from data provided by the state wildlife agencies, when available. This population data (Section B.2.3., Population [Demographics] Monitoring) will be used to answer Question 3 of the National Planning Strategy Effectiveness Report.

Calculating Question 4, National Planning Strategy Effectiveness: The estimated contribution by the BLM or the USFS to the change in the amount of sagebrush in the area of interest will use the information from Measure 1a (Section B.2.2.1, Sagebrush Availability). This measure is derived from the national datasets that remove sagebrush (Table B-1). To determine the relative contribution of BLM and USFS management, the current Surface Management Agency geospatial data layer will be used to differentiate the amount of change for each management agency for this measure in the geographic areas of interest. This information will be used to answer Question 4 of the National Planning Strategy Effectiveness Report.

Calculating Question 5, National Planning Strategy Effectiveness: The estimated contribution by the BLM or the USFS to the change in the amount of disturbance in the area of interest will use the information from Measure 2a (Section B.2.2.2, Monitoring Habitat Degradation) and Measure 3 (Section B.2.2.3, Energy and Mining Density). These measures are all derived from the national disturbance datasets that degrade habitat (Table B-6). To determine the relative contribution of BLM and USFS management, the current Surface Management Agency geospatial data layer will be used to differentiate the amount of change for each management agency for these two measures in the geographic areas of interest. This information will be used to answer Question 5 of the National Planning Strategy Effectiveness Report.

Answers to the five questions for determining the effectiveness of the national planning strategy will identify areas that appear to be meeting the objectives of the strategy and will facilitate identification of population areas for more detailed analysis. Conceptually, if the broad-scale monitoring identifies increasing sagebrush availability and improving vegetation conditions, decreasing disturbance, and a stable or increasing population for the area of interest, there is evidence that the objectives of the national planning strategy to maintain populations and their habitats have been met. Conversely, where information indicates that sagebrush is decreasing and vegetation conditions are degrading, disturbance in sage-grouse areas is increasing, and/or populations are declining relative to the baseline, there is evidence that the objectives of the national planning strategy are not being achieved. Such a determination would likely result in a more detailed analysis and could be the basis for implementing more restrictive adaptive management measures.

With respect to the land use plan area, the BLM and the USFS will summarize the vegetation, disturbance, and population data to determine if the LUP is meeting the plan objectives. Effectiveness information used for these evaluations includes BLM/USFS surface management areas and will help inform where finer-scale evaluations are needed, such as seasonal habitats, corridors, or linkage areas. Data will also include the trend of disturbance within the sage-grouse areas, which will inform the need to initiate adaptive management responses as described in the land use plan.

Calculating Question 1, Land Use Plan Effectiveness: The condition of vegetation and the allotments meeting land health standards (as articulated in “BLM Handbook 4180-1, Rangeland Health Standards”) in sage-grouse areas will be used to determine the LUP’s effectiveness in meeting the vegetation objectives for sage-grouse habitat set forth in the plan. The field office/ranger district will be responsible for collecting this data. In order for this data to be consistent and comparable, common indicators, consistent methods, and an unbiased sampling framework will be implemented following the principles in the BLM’s AIM strategy (Taylor et al. 2014; Toevs et al. 2011; MacKinnon et al. 2011), in the BLM’s Technical Reference “Interpreting Indicators of Rangeland Health” (Pellant et al. 2005), and in the HAF (Stiver et al. 2015. *in press*) or other approved WAFWA MZ–consistent guidance to measure and monitor sage- grouse habitats. This information will be used to answer Question 1 of the Land Use Plan Effectiveness Report.

Calculating Question 2, Land Use Plan Effectiveness: Sage-grouse areas within the LUP that are achieving land health stands (or, if trend data are available, that are making progress toward achieving them)—particularly the Special Status Species/wildlife habitat land health standard—will be used to determine the LUP's effectiveness in achieving the habitat objectives set forth in the plan. Field offices will follow directions in "BLM Handbook 4180-1, Rangeland Health Standards," to ascertain if sage-grouse areas are achieving or making progress toward achieving land health standards. One of the recommended criteria for evaluating this land health standard is the HAF indicators.

Calculating Question 3, Land Use Plan Effectiveness: The amount of habitat disturbance in sage-grouse areas identified in this LUP will be used to determine the LUP's effectiveness in meeting the plan's disturbance objectives. National datasets can be used to calculate the amount of disturbance, but field office data will likely increase the accuracy of this estimate. This information will be used to answer Question 3 of the Land Use Plan Effectiveness Report.

Calculating Question 4, Land Use Plan Effectiveness: The change in estimated sage-grouse populations will be calculated from data provided by the state wildlife agencies, when available, and will be used to determine LUP effectiveness. This population data (Section B.2.3, Population [Demographics] Monitoring) will be used to answer Question 4 of the Land Use Plan Effectiveness Report.

Results of the effectiveness monitoring process for the LUP will be used to inform the need for finer-scale investigations, initiate adaptive management actions as described in the land use plan, initiate causation determination, and/or determine if changes to management decisions are warranted. The measures used at the broad and mid scales will provide a suite of characteristics for evaluating the effectiveness of the adaptive management strategy.

B.3 FINE and SITE SCALES

Fine-scale (third-order) habitat selected by sage-grouse is described as the physical and geographic area within home ranges during breeding, summer, and winter periods. At this level, habitat suitability monitoring should address factors that affect sage-grouse use of, and movements between, seasonal use areas. The habitat monitoring at the fine and site scale (fourth order) should focus on indicators to describe seasonal home ranges for sage-grouse associated with a lek or lek group within a population or subpopulation area. Fine- and site-scale monitoring will inform LUP effectiveness monitoring (see Section B.2.4, Effectiveness Monitoring) and the hard and soft triggers identified in the LUP's adaptive management section.

Site-scale habitat selected by sage-grouse is described as the more detailed vegetation characteristics of seasonal habitats. Habitat suitability characteristics include canopy cover and height of sagebrush and the associated understory vegetation. They also include vegetation associated with riparian areas, wet meadows, and other mesic habitats adjacent to sagebrush that may support sage-grouse habitat needs during different stages in their annual cycle.

As described in the Conclusion (B.4), details and application of monitoring at the fine and site scales will be described in the implementation-level monitoring plan for the land use plan. The need for fine- and site-scale-specific habitat monitoring will vary by area, depending on proposed projects, existing conditions, habitat variability, threats, and land health. Examples of fine- and site-scale monitoring include: habitat vegetation monitoring to assess current habitat conditions; monitoring and evaluation of the success of projects targeting sage-grouse habitat enhancement and/or restoration; and habitat disturbance monitoring to provide localized disturbance measures to inform proposed project review and potential mitigation for project impacts. Monitoring plans should incorporate the principles outlined in the BLM's AIM strategy (Toevs et al. 2011) and in "AIM-Monitoring: A Component of the Assessment, Inventory, and Monitoring Strategy" (Taylor et al. 2014). Approved monitoring methods are:

- "BLM Core Terrestrial Indicators and Methods" (MacKinnon et al. 2011);
- The BLM's Technical Reference "Interpreting Indicators of Rangeland Health" (Pellant et al. 2005); and,
- "Sage-Grouse Habitat Assessment Framework: Multiscale Assessment Tool" (Stiver et al. 2015 *in press*).

Other state-specific disturbance tracking models include: the BLM's Wyoming Density and Disturbance Calculation Tool (http://ddct.wygisc.org/) and the BLM's White River Data Management System in development with the USGS. Population monitoring data (in cooperation with state wildlife agencies) should be included during evaluation of the effectiveness of actions taken at the fine and site scales.

Fine- and site-scale sage-grouse habitat suitability indicators for seasonal habitats are identified in the HAF. The HAF has incorporated the Connelly et al. (2000) sage-grouse guidelines as well as many of the core indicators in the AIM strategy (Toevs et al. 2011). There may be a need to develop adjustments to height and cover or other site suitability values described in the HAF; any such adjustments should be ecologically defensible. To foster consistency, however, adjustments to site suitability values at the local scale should be avoided unless there is strong, scientific justification for making those adjustments. That justification should be provided. WAFWA MZ adjustments must be supported by regional plant productivity and habitat data for the floristic province. If adjustments are made to the site-scale indicators, they must be made using data from the appropriate seasonal habitat designation (breeding/nesting, brood-rearing, winter) collected from sage-grouse studies found in the relevant area and peer-reviewed by the appropriate wildlife management agency(ies) and researchers.

When conducting land heath assessments, the BLM should follow, at a minimum, "Interpreting Indicators of Rangeland Health" (Pellant et. al. 2005) and the "BLM Core Terrestrial Indicators and Methods" (MacKinnon et al. 2011). For assessments being conducted in sage-grouse designated management areas, the BLM should collect additional data to inform the HAF indicators that have not been collected using the above methods. Implementation of the principles outlined in the AIM strategy will allow the data to be used to generate unbiased estimates of condition across the area of interest; facilitate consistent data collection and rollup analysis among management units; help provide consistent data to inform the classification and interpretation of imagery; and provide condition and trend of the indicators describing sagebrush characteristics important to sage-grouse habitat (see Section B.2.4, Effectiveness Monitoring).

B.4 CONCLUSION

This Greater Sage-Grouse Monitoring Framework was developed for all of the Final Environmental Impact Statements involved in the sage-grouse planning effort. As such, it describes the monitoring activities at the broad and mid scales and provides a guide for the BLM and the USFS to collaborate with partners/other agencies to develop the land use plan- specific monitoring plan.

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Attachment A: AN OVERVIEW OF MONITORING COMMITMENTS

	Broad and Mid-scales					Fine & Site Scales
	Implementation	**Vegetation**	**Disturbance**	**Population**	**Effectiveness**	
How will the data be used?	Track and document implementation of land use plan decisions and inform adaptive management	Track changes in land cover (sagebrush) and inform adaptive management	Track changes in disturbance (threats) to sage-grouse habitat and inform adaptive management	Track trends in sage-grouse populations (and/or leks; as determined by state wildlife agencies) and inform adaptive management	Characterize the relationship among disturbance, implementation actions, and sagebrush metrics and inform adaptive management	Measure seasonal habitat, connectivity at the fine scale, calculate disturbance, and inform adaptive management
Who is collecting the data?	BLM FO and USFS Forest	NOC and NIFC	National data sets (NOC), BLM FOs and USFS Forests as applicable	State wildlife agencies through WAFWA	Comes from other broad- and mid-scale monitoring types, analyzed by the NOC	BLM FO and SO, USFS Forests and RO (with partners)
How often are the data collected, reported, and made available to USFWS?	Collected and reported annually; summary report every 5 years	Updated and changes reported annually; summary report every 5 years	Collected and changes reported annually; summary report every 5 years	State data reported annually per WAFWA MOU; summary report every 5 years	Collected and reported every 5 years (coincident with LUP evaluations)	Collection and trend analysis ongoing, reported every 5 years or as needed to inform adaptive management
What is the spatial scale?	Summarized by LUP with flexibility for reporting by other units	Summarized by PACs (size dependent) with flexibility for reporting by other units	Summarized by PACs (size dependent) with flexibility for reporting by other units	Summarized by PACs (size dependent) with flexibility for reporting by other units	Summarized by MZ and LUP with flexibility for reporting by other units (e.g., PAC)	Variable (e.g., projects and seasonal habitats)
What are the potential personnel and budget impacts?	Additional capacity or re-prioritization of ongoing monitoring work and budget realignment	At a minimum, current skills and capacity must be maintained; data management costs are TBD	At a minimum, current skills and capacity must be maintained; data management and data layer purchase cost are TBD	No additional personnel or budget impacts for BLM or USFS	Additional capacity or re-prioritization of ongoing monitoring work and budget realignment	Additional capacity or re-prioritization of ongoing monitoring work and budget realignment
Who has primary and secondary responsibilities for reporting?	1) BLM FO & SO; USFS Forest & RO 2) BLM & FS Planning	1) NOC 2) WO	1) NOC 2) BLM SO, USFS RO & appropriate programs	1) WAFWA & state wildlife agencies 2) BLM SO, USFS RO, NOC	1) Broad and mid-scale at the NOC, LUP at BLM SO, USFS RO	1) BLM FO & USFS Forests 2) BLM SO & FS RO
What new processes/ tools will be needed?	National implementation data sets and analysis tools	Updates to national land cover data	Data standards and roll-up methods for these data	Standards in population monitoring (WAFWA)	Reporting methodologies	Data standards data storage; and reporting

FO (field office); NIFC (National Interagency Fire Center); NOC (National Operations Center); RO (regional office); SO (state office); TBD (to be determined); WO (Washington Office)

Attachment B - User and Producer Accuracies for Aggregated Ecological Systems within LANDFIRE Map Zones

LANDFIRE Map Zone Name	User Accuracy	Producer Accuracy	% of Map Zone within Historical Schroeder
Wyoming Basin	76.9%	90.9%	98.5%
Snake River Plain	68.8%	85.2%	98.4%
Missouri River Plateau	57.7%	100.0%	91.3%
Grand Coulee Basin of the Columbia Plateau	80.0%	80.0%	89.3%
Wyoming Highlands	75.3%	85.9%	88.1%
Western Great Basin	69.3%	75.4%	72.9%
Blue Mountain Region of the Columbia Plateau	85.7%	88.7%	72.7%
Eastern Great Basin	62.7%	80.0%	62.8%
Northwestern Great Plains	76.5%	92.9%	46.3%
Northern Rocky Mountains	72.5%	89.2%	42.5%
Utah High Plateaus	81.8%	78.3%	41.5%
Colorado Plateau	65.3%	76.2%	28.8%
Middle Rocky Mountains	78.6%	73.3%	26.4%
Cascade Mountain Range	57.1%	88.9%	17.3%
Sierra Nevada Mountain Range	0.0%	0.0%	12.3%
Northwestern Rocky Mountains	66.7%	60.0%	7.3%
Southern Rocky Mountains	58.6%	56.7%	7.0%
Northern Cascades	75.0%	75.0%	2.6%
Mogollon Rim	66.7%	100.0%	1.7%
Death Valley Basin	0.0%	0.0%	1.2%

There are two anomalous map zones with 0% user and producer accuracies, attributable to no available reference data for the ecological systems of interest.

User accuracy is a map-based accuracy that is computed by looking at the reference data for a class and determining the percentage of correct predictions for these samples. For example, if I select any sagebrush pixel on the classified map, what is the probability that I'll be standing in a sagebrush stand when I visit that pixel location in the field? **Commission Error** equates to including a pixel in a class when it should have been excluded (i.e., commission error = 1 – user’s accuracy).

Producer accuracy is a reference-based accuracy that is computed by looking at the predictions produced for a class and determining the percentage of correct predictions. In other words, if I know that a particular area is sagebrush (I've been out on the ground to check), what is the probability that the digital map will correctly identify that pixel as sagebrush? **Omission Error** equates to excluding a pixel that should have been included in the class (i.e., omission error = 1 – producer’s accuracy).

Attachment C. Sagebrush Species and Subspecies Included in the Selection Criteria for Building the EVT and BpS Layers

- *Artemisia arbuscula* subspecies *longicaulis*
- *Artemisia arbuscula* subspecies *longiloba*
- *Artemisia bigelovii*
- *Artemisia nova*
- *Artemisia papposa*
- *Artemisia pygmaea*
- *Artemisia rigida*
- *Artemisia spinescens*
- *Artemisia tripartita* subspecies *rupicola*
- *Artemisia tripartita* subspecies *tripartita*
- *Tanacetum nuttallii*
- *Artemisia cana* subspecies *bolanderi*
- *Artemisia cana* subspecies *cana*
- *Artemisia cana* subspecies *viscidula*
- *Artemisia tridentata* subspecies *wyomingensis*
- *Artemisia tridentata* subspecies *tridentata*
- *Artemisia tridentata* subspecies *vaseyana*
- *Artemisia tridentata* subspecies *spiciformis*
- *Artemisia tridentata* subspecies *xericensis*
- *Artemisia tridentata* variety *pauciflora*
- *Artemisia frigida*
- *Artemisia pedatifida*

C. Greater Sage-Grouse (GRSG) Disturbance Caps

In the USFWS's 2010 listing decision for sage-grouse, the USFWS identified 18 threats contributing to the destruction, modification, or curtailment of the sage-grouse's habitat or range (75 FR 13910 2010. The 18 threats have been aggregated into three measures:

Sagebrush Availability (percent of sagebrush per unit area)
Habitat Degradation (percent of human activity per unit area)
Density of Energy and Mining (facilities and locations per unit area)

Habitat Degradation and Density of Energy and Mining will be evaluated under the Disturbance Cap and Density Cap respectively and are further described in this appendix. The three measures, in conjunction with other information, will be considered during the NEPA process for projects authorized or undertaken by the BLM.

C.1 Disturbance Cap:

This land use plan has incorporated a 3% anthropogenic disturbance cap within Greater Sage-Grouse (GRSG) Priority Habitat Management Areas (PHMAs) and the subsequent land use planning actions if the cap is met:

If the 3% anthropogenic disturbance cap is exceeded on lands (regardless of land ownership) within GRSG Priority Habitat Management Areas (PHMA) in any given Biologically Significant Unit (BSU), then no further discrete anthropogenic disturbances (subject to applicable laws and regulations, such as the 1872 hard rock mining law, valid existing rights, etc.) will be permitted by BLM within GRSG PHMAs in any given BSU until the disturbance has been reduced to less than the cap.

If the 3% disturbance cap is exceeded on all lands (regardless of land ownership) or if anthropogenic disturbance and habitat loss associated with conversion to agricultural tillage or fire exceed 5% within a proposed project analysis area in a Priority Habitat Management Areas, then no further anthropogenic disturbance will be permitted by BLM until disturbance in the proposed project analysis area has been reduced to maintain the area under the cap (subject to applicable laws and regulations, such as the 1872 hard rock Mining Law, valid existing rights, etc.). If the BLM determines that the State of Montana's GRSG Habitat Conservation Program contains comparable components to those found in the State of Wyoming's Density and Disturbance model (an all lands approach for calculating anthropogenic disturbances, a clear methodology for measuring the density of operations, and a fully operational Density Disturbance Calculation Tool), the 3% disturbance cap will be converted to a 5% cap.

The disturbance cap applies to the PHMA within both the Biologically Significant Units (BSU) and at the project authorization scale. For the BSUs, west-wide habitat degradation (disturbance) data layers (Table C-1) will be used at a minimum to calculate the amount of disturbance and to determine if the disturbance cap has been exceeded as the land use plans (LUP) are being implemented. Locally collected disturbance data will be used to determine if the disturbance cap has been exceeded for project authorizations, and may also be used to calculate the amount of disturbance in the BSUs.

Although locatable mine sites are included in the degradation calculation, mining activities under the 1872 mining law may not be subject to the 3% disturbance cap. Details about locatable mining activities will be fully disclosed and analyzed in the NEPA process to assess impacts to sage-grouse and their habitat as well as to BLM goals and objectives, and other BLM programs and activities.

Formulas for calculations of the amount of disturbance in the PHMA in a BSU and or in a proposed project area are as follows:

- For the BSUs:
  % Degradation Disturbance = (combined acres of the 12 degradation threats[1]) ÷ (acres of all lands within the PHMAs in a BSU) x 100.

- For the Project Analysis Area:
  % Degradation Disturbance = (combined acres of the 12 degradation threats[1] plus the 7 site scale threats[2] and acres of habitat loss[1]) ÷ (acres of all lands within the PHMA in the project analysis area) x 100.
  [1] see Table C-1. [2] see Table C-2

The denominator in the disturbance calculation formula consists of all acres of lands classified as PHMA within the analysis area (BSU or project area). Areas that are not sage-grouse seasonal habitats, or are not currently supporting sagebrush cover (e.g., due to wildfire), are not excluded from the acres of PHMA in the denominator of the formula. Information regarding sage-grouse seasonal habitats, sagebrush availability, and areas with the potential to support sage-grouse populations will be considered along with other local conditions that may affect sage-grouse during the analysis of the proposed project area.

C.2 Density Cap:

This land use plan has also incorporated a cap on the density of energy and mining facilities at an average of one facility per 640 acres in the PHMA in a project authorization area. If the disturbance density in the PHMA in a proposed project area is on average less than 1 facility per 640 acres, the analysis will proceed through the NEPA process incorporating mitigation measures into an alternative. If the disturbance density is greater than an average of 1 facility per 640 acres, the proposed project will either be deferred until the density of energy and mining facilities is less than the cap or co-located it into existing disturbed area (subject to applicable laws and regulations, such as the 1872 Mining Law, valid existing rights, etc.). Facilities included in the density calculation (Table 3) are:

- Energy (oil and gas wells and development facilities)
- Energy (coal mines)

- Energy (wind towers)
- Energy (solar fields)
- Energy (geothermal)
- Mining (active locatable, leasable, and saleable developments)

<u>Project Analysis Area Method for Permitting Surface Disturbance Activities</u>:

- Determine potentially affected occupied leks by placing a four mile boundary around the proposed area of physical disturbance related to the project. All occupied leks located within the four mile project boundary and within PHMA will be considered affected by the project.
- Next, place a four mile boundary around each of the affected occupied leks.
- The PHMA within the four mile lek boundary and the four mile project boundary creates the project analysis area for each individual project. If there are no occupied leks within the four-mile project boundary, the project analysis area will be that portion of the four-mile project boundary within the PHMA.
- Digitize all existing anthropogenic disturbances identified in Table C-1, the 7 additional features that are considered threats to sage-grouse (Table C-2), and areas of sagebrush loss. Using 1 meter resolution NAIP imagery is recommended. Use existing local data if available.
- Calculate percent existing disturbance using the formula above. If existing disturbance is less than 3% anthropogenic disturbance or 5% total disturbance, proceed to next step. If existing disturbance is greater than 3% anthropogenic disturbance or 5% total disturbance, defer the project.
- Add proposed project disturbance footprint area and recalculate the percent disturbance. If disturbance is less than 3% anthropogenic disturbance or 5% total disturbance, proceed to next step. If disturbance is greater than 3% anthropogenic disturbance or 5% total disturbance, defer project.
- Calculate the disturbance density of energy and mining facilities (listed above). If the disturbance density is less than 1 facility per 640 acres, averaged across project analysis area, proceed to the NEPA analysis incorporating mitigation measures into an alternative. If the disturbance density is greater than 1 facility per 640 acres, averaged across the project analysis area, either defer the proposed project or co-locate it into existing disturbed area.
- If a project that would exceed the degradation cap or density cap cannot be deferred due to valid existing rights or other existing laws and regulations, fully disclose the local and regional impacts of the proposed action in the associated NEPA.

Table C-1: Anthropogenic disturbance types for disturbance calculations. Data sources are described for the west-wide habitat degradation estimates (Table copied from the GRSG Monitoring Framework)

Degradation Type	Subcategory	Data Source	Direct Area of Influence	Area Source
Energy (oil & gas)	Wells	IHS; BLM (AFMSS)	5.0ac (2.0ha)	BLM WO-300
	Power Plants	Platts (power plants)	5.0ac (2.0ha)	BLM WO-300
Energy (coal)	Mines	BLM; USFS; Office of Surface Mining Reclamation and Enforcement; USGS Mineral Resources Data System	Polygon area (digitized)	Esri/ Google Imagery
	Power Plants	Platts (power plants)	Polygon area (digitized)	Esri Imagery
Energy (wind)	Wind Turbines	Federal Aviation Administration	3.0ac (1.2ha)	BLM WO-300
	Power Plants	Platts (power plants)	3.0ac (1.2ha)	BLM WO-300
Energy (solar)	Fields/Power Plants	Platts (power plants)	7.3ac (3.0ha)/MW	NREL
Energy (geothermal)	Wells	IHS	3.0ac (1.2ha)	BLM WO-300
	Power Plants	Platts (power plants)	Polygon area (digitized)	Esri Imagery
Mining	Locatable Developments	InfoMine	Polygon area (digitized)	Esri Imagery
Infrastructure (roads)	Surface Streets (Minor Roads)	Esri StreetMap Premium	40.7ft (12.4m)	USGS
	Major Roads	Esri StreetMap Premium	84.0ft (25.6m)	USGS
	Interstate Highways	Esri StreetMap Premium	240.2ft (73.2m)	USGS
Infrastructure (railroads)	Active Lines	Federal Railroad Administration	30.8ft (9.4m)	USGS
Infrastructure (power lines)	1-199kV Lines	Platts (transmission lines)	100ft (30.5m)	BLM WO-300
	200-399 kV Lines	Platts (transmission lines)	150ft (45.7m)	BLM WO-300
	400-699kV Lines	Platts (transmission lines)	200ft (61.0m)	BLM WO-300
	700+kV Lines	Platts (transmission lines)	250ft (76.2m)	BLM WO-300
Infrastructure (communication)	Towers	Federal Communications Commission	2.5ac (1.0ha)	BLM WO-300

Table C-2: The seven site scale features considered threats to sage-grouse included in the disturbance calculation for project authorizations.

1. Coalbed Methane Ponds
2. Meteorological Towers
3. Nuclear Energy Facilities
4. Airport Facilities and Infrastructure
5. Military Range Facilities & Infrastructure
6. Hydroelectric Plants
7. Recreation Areas Facilities and Infrastructure

Definitions:

1. Coalbed Methane and other Energy-related Retention Ponds – The footprint boundary will follow the fenceline and includes the area within the fenceline surrounding the impoundment. If the pond is not fenced, the impoundment itself is the footprint. Other infrastructure associated with the containment ponds (roads, well pads, etc.) will be captured in other disturbance categories.

2. Meteorological Towers – This feature includes long-term weather monitoring and temporary meteorological towers associated with short-term wind testing. The footprint boundary includes the area underneath the guy wires.

3. Nuclear Energy Facilities – The footprint boundary includes visible facilities (fence, road, etc.) and undisturbed areas within the facility's perimeter.

4. Airport Facilities and Infrastructure (public and private) –The footprint boundary of will follow the boundary of the airport or heliport and includes mowed areas, parking lots, hangers, taxiways, driveways, terminals, maintenance facilities, beacons and related features. Indicators of the boundary, such as distinct land cover changes, fences and perimeter roads, will be used to encompass the entire airport or heliport.

5. Military Range Facilities & Infrastructure – The footprint boundary will follow the outer edge of the disturbed areas around buildings and includes undisturbed areas within the facility's perimeter.

6. Hydroelectric Plants – The footprint boundary includes visible facilities (fence, road, etc.) and undisturbed areas within the facility's perimeter.

7. Recreation Areas & Facilities – This feature includes all sites/facilities larger than 0.25 acres in size. The footprint boundary will include any undisturbed areas within the site/facility.

Table C-3: Relationship between the 18 threats and the three habitat disturbance measures for monitoring and disturbance calculations.

USFWS Listing Decision Threat	Sagebrush Availability	Habitat Degradation	Energy and Mining Density
Agriculture	X		
Urbanization	X		
Wildfire	X		
Conifer encroachment	X		
Treatments	X		
Invasive Species	X		
Energy (oil and gas wells and development facilities)		X	X
Energy (coal mines)		X	X
Energy (wind towers)		X	X
Energy (solar fields)		X	X
Energy (geothermal)		X	X
Mining (active locatable, leasable, and saleable developments)		X	X
Infrastructure (roads)		X	
Infrastructure (railroads)		X	
Infrastructure (power lines)		X	
Infrastructure (communication towers)		X	
Infrastructure (other vertical structures)		X	
Other developed rights-of-way		X	

D. Greater Sage-Grouse Effects Analysis Process

D.1 Effects Analysis Process

The BLM/USFS will ensure that any activities or projects in greater sage-grouse habitats would: 1) only occur in compliance with [insert plan name] greater sage-grouse goals and objectives for priority and general management areas; and 2) maintain neutral or positive greater sage-grouse population trends and habitat by avoiding, minimizing, and offsetting unavoidable impacts to assure a conservation gain at the scale of this land use plan and within greater sage-grouse population areas, State boundaries, and WAFWA Management Zones through the application of mitigation for implementation-level decisions. The mitigation process will follow the regulations from the White House Council on Environmental Quality (CEQ) (40 CFR 1508.20; e.g. avoid, minimize, and compensate), hereafter referred to as the mitigation hierarchy, while also following Secretary of the Interior Order 3330 and consulting BLM, FWS and other current and appropriate mitigation guidance . If it is determined that residual impacts to greater sage-grouse from implementation-level actions would remain after applying avoidance and minimization measures to the extent possible, then compensatory mitigation projects will be used to offset residual impacts, or the project may be deferred or denied if necessary to achieve the goals and objectives for priority and general management areas in the [insert plan name].

To ensure that impacts from activities proposed in sage-grouse priority and general management areas (PHMA and GHMA) are appropriately mitigated, the BLM will apply mitigation measures and conservation actions and potentially modify the location, design, construction, and/or operation of proposed land uses or activities to comply with statutory requirements for environmental protection. The mitigation measures and conservation actions [Appendix AA, section F] for proposed projects or activities in these areas will be identified as part of the National Environmental Policy Act (NEPA) environmental review process, through interdisciplinary analysis involving resource specialists, project proponents, government entities, landowners or other Surface Management Agencies. Those measures selected for implementation will be identified in the Record of Decision (ROD) or Decision Record (DR) for those authorizations and will inform a potential lessee, permittee, or operator of the requirements that must be met when using BLM-administered public lands and minerals to mitigate, per the mitigation hierarchy referenced above, impacts from the activity or project such that sage-grouse goals and objectives are met. Because these actions create a clear obligation for the BLM to ensure any proposed mitigation action adopted in the environmental review process is performed, there is assurance that mitigation will lead to a reduction of environmental impacts in the implementation stage and include binding mechanisms for enforcement (CEQ Memorandum for Heads of Federal Departments and Agencies 2011).

To achieve the goals and objectives for PHMA and GHMA in the [insert plan name], the BLM will assess all proposed land uses or activities such as road, pipeline, communication tower, or powerline construction, fluid and solid mineral development, range improvements, and recreational activities proposed for location in sage-grouse PHMA and GHMA in a step-wise manner. The following steps identify a screening process for review of proposed activities or projects in these areas. This process will provide a consistent approach and ensure that authorization of these projects, if granted, will appropriately mitigate impacts and be consistent with the LUP goals and objectives for sage-grouse. The following steps provide for a sequential screening of proposals. However, Steps 2-6 can be done concurrently.

D.1.1 Step 1 – Determine Proposal Adequacy

This screening process is initiated upon formal submittal of a proposal for authorization for use of BLM lands. The actual documentation of the proposal would include at a minimum a description of the location, scale of the project and timing of the disturbance. The acceptance of the proposal(s) for review would be consistent with existing protocol and procedures for each type of use.

D.1.2 Step 2 – Evaluate Proposal Consistency with LUP

This initial review should evaluate whether the proposal would be allowed as prescribed in the Land Use Plan. For example, some activities or types of development are prohibited in PHMA or GHMA. Evaluation of projects will also include an assessment of the current state of the Adaptive Management hard and soft triggers. If the proposal is for an activity that is specifically prohibited, the applicant should be informed that the application is being rejected since it would not be allowed, regardless of the design of the project.

D.1.3 Step 3 – Determine Proposal Consistency with Density and Disturbance Limitations

If the proposed activity occurs within a PHMA, evaluate whether the disturbance from the activity exceeds the limit on the amount of disturbance allowed within the activity or project area (DDCT process). If current disturbance within the activity area or the anticipated disturbance from the proposed activity exceeds this threshold, the project would be deferred until such time as the amount of disturbance within the area has been reduced below the threshold, redesigned so as to not result in any additional surface disturbance (collocation) or redesigned to move it outside of PHMA.

D.1.4 Step 4 – Determine Projected Sage-Grouse Population and Habitat Impacts

Determine if the project will have a direct or indirect impact on sage-grouse populations or habitat within PHMA or GHMA. This will include:

- Reviewing Greater Sage-Grouse Habitat delineation maps to initially assess potential impacts to sage-grouse.
  Use of the *USGS report Conservation Buffer Distance Estimates for Greater Sage-Grouse—A Review* to assess potential project impacts based upon the distance to the

nearest lek, using the most recent active lek data available from the state wildlife agency. This assessment will be based upon the direction in Appendix [insert buffer appendix reference]:

- Review and application of current science recommendations.
- Reviewing the 'Base Line Environment Report' (USGS) which identifies areas of direct and indirect effect for various anthropogenic activities.
- Consultation with agency or State Wildlife Agency biologist.
- Evaluating consistency with (at a minimum) State sage-grouse regulations
- Or other methods needed to provide an accurate assessment of impacts.

If the proposal will not have a direct or indirect impact on either the habitat or population, document the findings in the NEPA and proceed with the appropriate process for review, decision and implementation of the project.

D.1.5 Step 5 –Apply Avoidance and Minimization Measures to Comply with Sage-Grouse Goals and Objectives

If the project can be relocated so as to not have an impact on sage-grouse and still achieve objectives of the proposal and the disturbance limitations, relocate the proposed activity and proceed with the appropriate process for review, decision and implementation (NEPA and Decision Record). This Step does not consider redesign of the project to reduce or eliminate direct and indirect impacts, but rather authorization of the project in a physical location that will not impact Greater Sage-Grouse. If the preliminary review of the proposal concludes that there may be adverse impacts to sage-grouse habitat or populations in Step 4 and the project cannot be effectively relocated to avoid these impacts, proceed with the appropriate process for review, decision and implementation (NEPA and Decision Record) with the inclusion of appropriate mitigation requirements to further reduce or eliminate impacts to sage-grouse habitat and populations and achieve compliance with sage-grouse objectives. Mitigation measures could include disturbance buffer limits, timing of disturbance limits, noise restrictions, design modifications of the proposal, site disturbance restoration, post project reclamation, etc (see Mitigation Measures and Conservation Actions Appendix [Appendix AA, section F] for a more complete list of measures). Compensatory or offsite mitigation may be required (Step 6) in situations where residual impacts remain after application of all avoidance and minimization measures.

D.1.6 Step 6 – Apply Compensatory Mitigation or Reject / Defer Proposal

If screening of the proposal (Steps 1-5) has determined that direct and indirect impacts cannot be eliminated through avoidance or minimization, evaluate the proposal to determine if compensatory mitigation can be used to offset the remaining adverse impacts and achieve sage-grouse goals and objectives. <u>If the impacts cannot be effectively mitigated, reject or defer the proposal</u>. The criteria for determining this situation could include but are not limited to:

- The current trend within the Priority Habitat is down and additional impacts, whether mitigated or not, could lead to further decline of the species or habitat.
- The proposed mitigation is inadequate in scope or duration, has proven to be ineffective or is unproven is terms of science based approach.
- The project would impact habitat that has been determined to be a limiting factor for species sustainability.
- Other site specific information and analysis that determined the project would lead to a downward change of the current species population or habitat and not comply with sage-grouse goals and objectives.

If, following application of available impact avoidance and minimization measures, the project can be mitigated to fully offset impacts and assure conservation gain to the species and comply with sage-grouse goals and objectives, proceed with the appropriate process for review, decision and implementation (NEPA and Decision Record).

The BLM/USFS, via the WAFWA Management Zone Greater Sage-Grouse Conservation Team, will develop a WAFWA Management Zone Regional Mitigation Strategy to guide the application of the mitigation hierarchy to address greater sage-grouse impacts within that Zone. The WAFWA Management Zone Regional Mitigation Strategy will be applicable to the States/Field Offices/Forests within the Zone’s boundaries. Subsequently, the BLM Billings Field Office’s NEPA analyses for implementation-level decisions, which have the potential to impact greater sage-grouse, will include analysis of mitigation recommendations from the relevant WAFWA Management Zone Regional Mitigation Strategy(ies).

Implementation of the Regional Mitigation Strategy may involve managing compensatory mitigation funds, implementing compensatory mitigation projects, certifying mitigation/conservation banks, and reporting on the effectiveness of those projects. These types of mitigation implementation actions may be most effectively managed at the State-level, in collaboration with partners. BLM State Office/USFS Region may find it most effective to enter into an agreement with a State-level program administrator (e.g. a NGO, a State-level entity) to help manage these aspects of mitigation. The BLM/USFS will remain responsible for making decisions that affect Federal lands.

The BLM’s Regional Mitigation Manual MS-1794 serves as a framework for developing and implementing a Regional Mitigation Strategy. The Appendix AA, Section E.2 provides additional guidance specific to the development and implementation of a WAFWA Management Zone Regional Mitigation Strategy.

E. MITIGATION

E.1 General

In undertaking BLM/USFS management actions, and, consistent with valid existing rights and applicable law, in authorizing third party actions that result in habitat loss and degradation, the BLM/USFS will require and ensure mitigation that provides a net conservation gain to the species including accounting for any uncertainty associated with the effectiveness of such mitigation. This will be achieved by avoiding, minimizing, and compensating for impacts by applying beneficial mitigation actions. Mitigation will follow the regulations from the White House Council on Environmental Quality (CEQ) (40 CFR 1508.20; e.g. avoid, minimize, and compensate), hereafter referred to as the mitigation hierarchy. If impacts from BLM/USFS management actions and authorized third party actions that result in habitat loss and degradation remain after applying avoidance and minimization measures (i.e. residual impacts), then compensatory mitigation projects will be used to provide a net conservation gain to the species. Any compensatory mitigation will be durable, timely, and in addition to that which would have resulted without the compensatory mitigation (see glossary).

The BLM/USFS, via the WAFWA Management Zone Greater Sage-Grouse Conservation Team, will develop a WAFWA Management Zone Regional Mitigation Strategy that will inform the NEPA decision making process including the application of the mitigation hierarchy for BLM/USFS management actions and third party actions that result in habitat loss and degradation. A robust and transparent Regional Mitigation Strategy will contribute to greater sage-grouse habitat conservation by reducing, eliminating, or minimizing threats and compensating for residual impacts to greater sage-grouse and its habitat.

The BLM's Regional Mitigation Manual MS-1794 serves as a framework for developing and implementing a Regional Mitigation Strategy. The following sections provide additional guidance specific to the development and implementation of a WAFWA Management Zone Regional Mitigation Strategy.

E.2 Developing a WAFWA Management Zone Regional Mitigation Strategy

The BLM/USFS, via the WAFWA Management Zone Greater Sage-Grouse Conservation Team, will develop a WAFWA Management Zone Regional Mitigation Strategy to guide the application of the mitigation hierarchy for BLM/USFS management actions and third party actions that result in habitat loss and degradation. The Strategy should consider any State-level greater sage-grouse mitigation guidance that is consistent with the requirements identified in this Appendix. The Regional Mitigation Strategy should be developed in a transparent manner, based on the best science available and standardized metrics.

As described in Chapter 2, the BLM/USFS will establish a WAFWA Management Zone Greater Sage-Grouse Conservation Team (hereafter, Team) to help guide the conservation of greater sage-grouse, within 90 days of the issuance of the Record of Decision. The Strategy will be developed within one year of the issuance of the Record of Decision.

The Regional Mitigation Strategy should include mitigation guidance on avoidance, minimization, and compensation, as follows:

- Avoidance
    - Include avoidance areas (e.g. right-of-way avoidance/exclusion areas, no surface occupancy areas) already included in laws, regulations, policies, and/or land use plans (e.g. Resource Management Plans, Forest Plans, State Plans); and,
    - Include any potential, additional avoidance actions (e.g. additional avoidance best management practices) with regard to greater sage-grouse conservation.
- Minimization
    - Include minimization actions (e.g. required design features, best management practices) already included in laws, regulations, policies, land use plans, and/or land-use authorizations; and,
    - Include any potential, additional minimization actions (e.g. additional minimization best management practices) with regard to greater sage-grouse conservation.
- Compensation
    - Include discussion of impact/project valuation, compensatory mitigation options, siting, compensatory project types and costs, monitoring, reporting, and program administration. Each of these topics is discussed in more detail below.
        - Residual Impact and Compensatory Mitigation Project Valuation Guidance
            - A common standardized method should be identified for estimating the value of the residual impacts and value of the compensatory mitigation projects, including accounting for any uncertainty associated with the effectiveness of the projects.
            - This method should consider the quality of habitat, scarcity of the habitat, and the size of the impact/project.
            - For compensatory mitigation projects, consideration of durability (see glossary), timeliness (see glossary), and the potential for failure (e.g. uncertainty associated with effectiveness) may require an upward adjustment of the valuation.
            - The resultant compensatory mitigation project will, after application of the above guidance, result in proactive conservation measures for Greater Sage-grouse (consistent with BLM Manual 6840 – Special Status Species Management, section .02).
        - Compensatory Mitigation Options
            - Options for implementing compensatory mitigation should be identified, such as:
                - Utilizing certified mitigation/conservation bank or credit exchanges.
                - Contributing to an existing mitigation/conservation fund.
                - Authorized-user conducted mitigation projects.
            - For any compensatory mitigation project, the investment must be additional (i.e. additionality: the conservation benefits of

compensatory mitigation are demonstrably new and would not have resulted without the compensatory mitigation project).

- Compensatory Mitigation Siting
    - Sites should be in areas that have the potential to yield a net conservation gain to the greater sage-grouse, regardless of land ownership.
    - Sites should be durable (see glossary).
    - Sites identified by existing plans and strategies (e.g. fire restoration plans, invasive species strategies, healthy land focal areas) should be considered, if those sites have the potential to yield a net conservation gain to greater sage-grouse and are durable.
- Compensatory Mitigation Project Types and Costs
    - Project types should be identified that help reduce threats to greater sage-grouse (e.g. protection, conservation, and restoration projects).
    - Each project type should have a goal and measurable objectives.
    - Each project type should have associated monitoring and maintenance requirements, for the duration of the impact.
    - To inform contributions to a mitigation/conservation fund, expected costs for these project types (and their monitoring and maintenance), within the WAFWA Management Zone, should be identified.
- Compensatory Mitigation Compliance and Monitoring
    - Mitigation projects should be inspected to ensure they are implemented as designed, and if not, there should be methods to enforce compliance.
    - Mitigation projects should be monitored to ensure that the goals and objectives are met and that the benefits are effective for the duration of the impact.
- Compensatory Mitigation Reporting
    - Standardized, transparent, scalable, and scientifically-defensible reporting requirements should be identified for mitigation projects.
    - Reports should be compiled, summarized, and reviewed in the WAFWA Management Zone in order to determine if greater sage-grouse conservation has been achieved and/or to support adaptive management recommendations.
- Compensatory Mitigation Program Implementation Guidelines
    - Guidelines for implementing the State-level compensatory mitigation program should include holding and applying compensatory mitigation funds, operating a transparent and credible accounting system, certifying mitigation credits, and managing reporting requirements.

<u>Incorporating the Regional Mitigation Strategy into NEPA Analyses</u>
The BLM/USFS will include the avoidance, minimization, and compensatory recommendations from the Regional Mitigation Strategy in one or more of the NEPA analysis' alternatives for BLM/USFS management actions and third party actions that result in habitat loss and degradation and the appropriate mitigation actions will be carried forward into the decision.

Implementing a Compensatory Mitigation Program

The BLM/USFS need to ensure that compensatory mitigation is strategically implemented to provide a net conservation gain to the species, as identified in the Regional Mitigation Strategy. In order to align with existing compensatory mitigation efforts, this compensatory mitigation program will be managed at a State-level (as opposed to a WAFWA Management Zone, a Field Office, or a Forest), in collaboration with our partners (e.g. Federal, Tribal, and State agencies).

To ensure transparent and effective management of the compensatory mitigation funds, the BLM/USFS will enter into a contract or agreement with a third-party to help manage the State-level compensatory mitigation funds, within one year of the issuance of the Record of Decision. The selection of the third-party compensatory mitigation administrator will conform to all relevant laws, regulations, and policies. The BLM/USFS will remain responsible for making decisions that affect Federal lands.

F. MITIGATION MEASURES

F.1 Introduction

The following Mitigation Measures and Conservation Actions are a compilation of Best Management Practices (BMPs), Required Design Features (RDFs), and/or operating procedures used by the BLM to meet statutory requirements for environmental protection and comply with resource specific Goals and Objectives set forward in this land use plan. The BLM will apply mitigation measures and conservation actions to modify the operations of authorized lands uses or activities to meet these obligations. Additional direction regarding mitigation can be found in the Interim Policy, Draft - Regional Mitigation Manual Section - 1794 (IM 2013-142) or subsequent decision documents.

These measures and actions will be applied to avoid, minimize, rectify, reduce, and compensate for impacts if an evaluation of the authorization area indicates the presence of resources of concern which include, but are not limited to air, water, soils, cultural resources, national historic trails, recreation values and important wildlife habitat in order to reduce impacts associated with authorized land uses or activities such as road, pipeline, or powerline construction, fluid and solid mineral development, range improvements, and recreational activities. The mitigation measures and conservation actions for authorizations will be identified as part of the National Environmental Policy Act (NEPA) process, through interdisciplinary analysis involving resource specialists, project proponents, government entities, landowners or other Surface Management Agencies. Those measures selected for implementation will be identified in the Record of Decision (ROD) or Decision Record (DR) for those authorizations and will inform a potential lessee, permittee, or operator of the requirements that must be met when using BLM-administered public lands and minerals to mitigate impacts from those authorizations. Because these actions create a clear obligation for the BLM to ensure any proposed mitigation action adopted in the environmental review process is performed, there is assurance that mitigation will lead to a reduction of environmental impacts in the implementation stage and include binding mechanisms for enforcement (CEQ Memorandum for Heads of Federal Departments and Agencies 2011).

Because of site-specific circumstances and localized resource conditions, some mitigation measures and conservation actions may not apply to some or all activities (e.g., a resource or conflict is not present on a given site) and/or may require slight variations from what is described in this appendix. The BLM may add additional measures as deemed necessary through the environmental analysis and as developed through coordination with other federal, state, and local regulatory and resource agencies. Application of mitigation measures and conservation actions is subject to valid existing rights, technical and economic feasibility.

Implementation and effectiveness of mitigation measures and conservation actions would be monitored to determine whether the practices are achieving resource objectives and accomplishing desired goals. Timely adjustments would be made as necessary to meet the resource goals and objectives.

The list included in this appendix is not limiting, but references the most frequently used sources. The BLM may add additional site-specific restrictions as deemed necessary by further environmental analysis and as developed through coordination with other federal, state, and local regulatory and resource agencies. Because mitigation measures and conservation actions change or are modified, based on new information, the guidelines will be updated periodically. As new publications are developed; the BLM may consider those BMPs. In addition, many BLM handbooks (such as BLM Manual 9113-Roads and 9213-Interagency Standards for Fire and Aviation Operation) also contain BMP-type measures for minimizing impacts. These BLM-specific guidance and direction documents are not referenced in this appendix. The EIS for this RMP does not decide or dictate the exact wording or inclusion of these mitigation measures and conservation actions. Rather, they are used in the RMP and EIS process as a tool to help demonstrate at the Land Use Plan scale how they will be applied in considering subsequent activity plans and site-specific authorizations. These mitigation measures and conservation actions and their wording are matters of policy. As such, specific wording is subject to change, primarily through administrative review, not through the RMP and EIS process. Any further changes that may be made in the continuing refinement of these mitigation measures and conservation actions and any development of program-specific standard procedures will be handled in another forum, including appropriate public involvement and input.

F.2 GENERAL MITIGATION MEASURES and CONSERVATION ACTION RESOURCES

F.2.1 Best Management Practices

Air Resource BMPs
Developed by: Bureau of Land Management
Publication reference: BLM/WO Updated May 9, 2011
Available from: Online at:
http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices/technical_information.html
Description: Identifies a range of typical Best Management Practices for protecting air resources during oil and gas development and production operations.

Erosion and Sediment Control Practices: Field Manual
Developed by: Prepared for the Montana Department of Transportation
Publication reference: FHWA/MT-030003/8165
Available from: National Technical Information Service, Springfield, VA 21161
Description: The Erosion and Sediment Control Best Management Practices Construction Field Manual was developed to assist in design, construction, and post-construction phases of MDT projects. This manual provides background to concepts of Erosion and Sediment Control. Most of MDTs Best Management Practices are listed within the manual based on application categories. Each BMP is described; its applications and limitations are listed, as well as its design criteria. Construction phase and post-construction phase BMPs are described. This manual is a field guide and condensed version of the Erosion and Sediment Control Design Construction Best Management Practices Manual. For more detailed discussion on topic found

within, refer to the Erosion and Sediment Control Construction Best Management Practices Manual.

Erosion and Sediment Control Practices: Reference Manual
Developed by: Prepared for the Montana Department of Transportation
Publication reference: FHWA/MT-030003/8165
Available from: National Technical Information Service, Springfield, VA 21161
Description: The Erosion and Sediment Control Construction Best Management Practices Manual was developed to assist in the design, construction, and post-construction phases of Montana Department of Transportation (MDT) projects. This manual provides background to State and Federal regulations associated with erosion and sediment control practices including a general overview of the erosion and sediment processes. Best management practices are listed within the manual based on application categories. Each BMP is described; its applications and limitations are listed, as well as its design criteria. The design phase includes development of construction plans, notice of intent (NOI), and stormwater pollution prevention plan (SWPPP). Construction phase includes the finalization of the SWPPP, NOI, and the implementation of BMPs. Post-construction phase includes monitoring, maintenance, and removal activities.

Fluid Minerals BMPs
Developed by: Bureau of Land Management
Publication reference: BLM/WO/ST-06/021+3071
Available from:
Online at: http://www.blm.gov/bmp/
Online at: http://www.mt.blm.gov/oilgas/operations/goldbook/goldbook1.html
Online at: http://www.mt.blm.gov/oilgas/operations/goldbook/Stand_Enviro_Color.pdf
Online at: http://www.mt.blm.gov/oilgas/operations/color.pdf
Description: BMPs for oil and gas demonstrate practical ideas which may eliminate or minimize adverse impacts from oil and gas development to public health and the environment, landowners, and natural resources; enhance the value of natural and landowner resources; and reduce conflict. The publication reference is to the "Gold Book" which is formally titled "Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development." In addition, the first internet citation is to a location maintained by the Washington Office of the BLM containing general and technical information on the use and application of BMPs. The second location refers the reader directly to an online version of the "Gold Book." The third and fourth locations refer the reader to color charts for use in selecting paint colors for oil and gas facilities.

Montana Guide to the Streamside Management Zone Law
Developed by: Montana Department of Natural Resources and Conservation Service Forestry Bureau, in cooperation with Montana Department of Environmental Quality, Montana Logging Association, Montana Wood Products Association, Plum Creek Timber LP, USDA Forest Service, USDI Bureau of Land Management
Publication reference: Revised August 2002
Available from: Montana Department of Natural Resources and Conservation, 2705 Spurgin Road, Missoula MT 59801-3199, (406)542-4300, or local MT DNRC field office.
Description: The Montana Guide to the Streamside Management Zone Law is a field guide to compliance with State of Montana Law 77-5-301[1] MCA.) Complementary BMPs are found in

the Water Quality BMPS for Montana Forests (also referenced in this appendix). Provides definitions, stream classifications, and guidelines on the seven forest practices prohibited by Montana law in SMZs (broadcast burning, operation of wheeled or tracked vehicles except on established roads, the forest practice of clearcutting, the construction of roads except when necessary to cross a stream or wetland; the handling, storage, application, or disposal of hazardous or toxic materials in a manner that pollutes streams, lakes, or wetlands, or that may cause damage or injury to humans, land, animals, or plants; the side casting of road material into a stream, lake, wetland, or watercourse; and the deposit of slash in streams, lakes, or other water bodies.

Montana Non-Point Source Management Plan
Developed by: Montana Department of Environmental Quality, Water Quality Planning Bureau, Watershed Protection Section
Publication reference: 2007
Available from: Montana Department of Environmental Quality, Water Quality Planning Bureau, Watershed Protection Section, P.O. Box 200901, Helena, MT 59620-0901.
Online at:
http://www.deq.state.mt.us/wqinfo/nonpoint/2007NONPOINTPLAN/Final/NPSPlan.pdf
Description: This document describes the Montana Department of Environmental Quality's (DEQ) updated strategy for controlling nonpoint source (NPS) water pollution, which is the state's single largest source of water quality impairment. NPS pollution is contaminated runoff from the land surface that can be generated by most land use activities, including agriculture, forestry, urban and suburban development, mining, and others. Common NPS pollutants include sediment, nutrients, temperature, heavy metals, pesticides, pathogens, and salt. The purpose of the Montana NPS Pollution Management Plan (Plan) is: 1) to inform the state's citizens about NPS pollution problems; and 2) to establish goals, objectives, and both long-term and short-term strategies for controlling NPS pollution on a statewide basis. The goal of Montana's NPS Management Program is to protect and restore water quality from the impacts of non-point sources of pollution in order to provide a clean and healthy environment.

Montana Placer Mining BMPs
Developed by: Montana Bureau of Mines and Geology
Publication reference: Special Publication 106, October 1993
Available from: Montana Bureau of Mines and Geology, Main Hall, Montana College of Mineral Science and Technology, Butte MT 59701
Description: Provides guidelines for planning, erosion control, and reclamation in arid to semi-arid, alpine, and subalpine environments, to prevent or decrease environmental damage and degradation of water quality.

Water Quality BMPs for Montana Forests
Developed by: Montana State University Extension Service
Publication reference: Logan, R. 2001. Water Quality BMPs – Best Management Practices for Montana Forests. EB158, MSU Extension Forestry, Missoula, MT. 58 pp.
Available from: MSU Extension Forestry, 32 Campus Dr., Missoula MT 59812, OR MSU Extension Publications, PO Box 172040 Bozeman MT 59717
Description: Discusses methods for managing forest land while protecting water quality and forest soils. Intended for all forest land in Montana, including non-industrial private, forest industry, and state or federally-owned forests. These are preferred (but voluntary) methods that go beyond Montana State Law (Streamside Management Zones). Includes definitions, basic biological information, and BMPs for Streamside Management Zones; road design, use, planning and locating, construction, drainage, and closure; stream crossings, soil, timber harvesting methods, reforestation, winter planning, and clean-up.

Wind Energy BMPs
Developed by: Bureau of Land Management
Publication reference: Wind Energy Development Programmatic EIS
Available from: FEIS Chapter 2 (section 2.2.3.2) at http://windeis.anl.gov/
Description: As part of the proposed action, BLM developed BMPs for each major step of the wind energy development process, including site monitoring and testing, plan of development preparation, construction, operation, and decommissioning. General BMPs are available for each step, and certain steps also include specific BMPs to address the following resource issues: wildlife and other ecological resources, Visual resources, Roads, Transportation, Noise, Noxious Weeds and Pesticides, Cultural/Historic Resources, Paleontological Resources, Hazardous Materials and Waste Management, Storm Water, Human Health and Safety, monitoring program, air emissions and excavation and blasting activities.

Communication Tower BMPs
Developed by: United States Fish and Wildlife Service
Publication reference: Service Guidance on the Siting, Construction, Operation and Decommissioning of Communications Towers
Available from: http://www.fws.gov/habitatconservation/com_tow_guidelines.pdf
Description: These guidelines were developed by Service personnel from research conducted in several eastern, midwestern, and southern States, and have been refined through Regional review. They are based on the best information available at this time, and are the most prudent and effective measures for avoiding bird strikes at towers.

- Any company/applicant/licensee proposing to construct a new communications tower should be strongly encouraged to collocate the communications equipment on an existing communication tower or other structure (e.g., billboard, water tower, or building mount). Depending on tower load factors, from 6 to 10 providers may collocate on an existing tower.
- If collocation is not feasible and a new tower or towers are to be constructed, communications service providers should be strongly encouraged to construct towers no more than 199 feet above ground level, using construction techniques which do not

require guy wires (e.g., use a lattice structure, monopole, etc.). Such towers should be unlighted if Federal Aviation Administration regulations permit.

- If constructing multiple towers, providers should consider the cumulative impacts of all of those towers to migratory birds and threatened and endangered species as well as the impacts of each individual tower.
- If at all possible, new towers should be sited within existing "antenna farms" (clusters of towers). Towers should not be sited in or near wetlands, other known bird concentration areas (e.g., State or Federal refuges, staging areas, rookeries), in known migratory or daily movement flyways, or in habitat ofthreatened or endangered species. Towers should not be sited in areas with a high incidence of fog, mist, and low ceilings.
- If taller (>199 feet AGL) towers requiring lights for aviation safety must be constructed, the minimum amount of pilot warning and obstruction avoidance lighting required by the FAA should be used. Unless otherwise required by the FAA, only white (preferable) or red strobe lights should be used at night, and these should be the minimum number, minimum intensity, and minimum number of flashes per minute (longest duration between flashes) allowable by the FAA. The use of solid red or pulsating red warning lights at night should be avoided. Current research indicates that solid or pulsating (beacon) red lights attract night-migrating birds at a much higher rate than white strobe lights. Red strobe lights have not yet been studied.
- Tower designs using guy wires for support which are proposed to be located in known raptor or waterbird concentration areas or daily movement routes, or in major diurnal migratory bird movement routes or stopover sites, should have daytime visual markers on the wires to prevent collisions by these diurnally moving species. (For guidance on markers, see Avian Power Line Interaction Committee (APLIC). 1994. Mitigating Bird Collisions with Power Lines: The State ofthe Art in 1994. Edison Electric Institute, Washington, D.c., 78 pp, and Avian Power Line Interaction Committee (APLIC). 1996. Suggested Practices/or Raptor Protection on Power Lines. Edison Electric Institute Raptor Research Foundation, Washington, D. C; 128 pp. Copies can be obtained via the Internet at http://www.eei.org/resources/pubcat/enviro/. or by calling 1-800/334-5453).
- Towers and appendant facilities should be sited, designed and constructed so as to avoid or minimize habitat loss within and adjacent to the tower "footprint." However, a larger tower footprint is preferable to the use of guy wires in construction. Road access and fencing should be minimized to reduce or prevent habitat fragmentation and disturbance, and to reduce above ground obstacles to birds in flight.
- If significant numbers of breeding, feeding, or roosting birds are known to habitually use the proposed tower construction area, relocation to an alternate site should be recommended. If this is not an option, seasonal restrictions on construction may be advisable in order to avoid disturbance during periods of high bird activity.
- In order to reduce the number of towers needed in the future, providers should be encouraged to design new towers structurally and electrically to accommodate the applicant/licensee's antennas and comparable antennas for at least two additional users (minimum of three users for each tower structure), unless this design would require the addition of lights or guy wires to an otherwise unlighted and/or unguyed tower.
- Security lighting for on-ground facilities and equipment should be down-shielded to keep light within the boundaries of the site.

- If a tower is constructed or proposed for construction, Service personnel or researchers from the Communication Tower Working Group should be allowed access to the site to evaluate bird use, conduct dead-bird searches, to place net catchments below the towers but above the ground, and to place radar, Global Positioning System, infrared, thermal imagery, and acoustical monitoring equipment as necessary to assess and verify bird movements and to gain information on the impacts of various tower sizes, configurations, and lighting systems.
- Towers no longer in use or determined to be obsolete should be removed within 12 months of cessation of use.

GRAZING MANAGEMENT BEST MANAGEMENT PRACTICES (Guidelines)
Guidelines for grazing management are the types of grazing management methods and practices determined to be appropriate to ensure that rangeland health standards can be met or significant progress can be made toward meeting the standards. Guidelines are best management practices (BMP), treatments, and techniques and implementation of range improvements that will help achieve rangeland health standards. Guidelines are flexible and are applied on site specific situations. Standards for Rangeland Health and Guidelines for Livestock Grazing Management for the [INSERT NAME] Field Office can be found at: [INSERT WEB ADDRESS]

BLM BMPs
The website below provides an introduction to BLM BMPs with links to BLM contacts, General BMP Information, BMP Frequently Asked Questions, BMP Technical Information, Oil and Gas Exploration—The Gold Book, Specific Resource BMPs, and, other BLM links.

- http://www.blm.gov/bmp/

Visual Resources
The website below provides numerous design techniques that can be used to reduce the visual impacts from surface-disturbing projects. The techniques described here should be used in conjunction with BLM's visual resource contrast rating process wherein both the existing landscape and the proposed development or activity are analyzed for their basic element of form, line, color, and texture.

- http://www.blm.gov/pgdata/content/wo/en/prog/Recreation/recreation_national/RMS.html

Renewable Energy Development
The following resources provide information on BMPs related to renewable energy development.

- Wind Energy Development Programmatic Environmental Impact Statement: http://windeis.anl.gov/documents/fpeis/index.cfm
- BLM Instruction Memorandum 2009-043, Rights-of-Way, Wind Energy: http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_instruction/2009/IM_2009-043.htm.
- Solar Energy Development Programmatic Environmental Impact Statement: http://www.solareis.anl.gov/

Healthy Watersheds

The website below provides conservation approaches and tools designed to ensure healthy watersheds remain intact. It also provides site-specific examples.

- http://www.epa.gov/owow/nps/

Storm Water BMPs

The website below provides BMPs designed to meet the minimum requirements for six control measures specified by the EPA's Phase II Stormwater Program.

- http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

Pasture, Rangeland, and Grazing Operations BMPs

The website below provides BMPs compiled by the EPA to prevent or reduce impacts associated with livestock grazing.

- http://www.epa.gov/oecaagct/anprgbmp.html

National Range and Pasture Handbook

The website below provides procedures in support of NRCS policy for the inventory, analysis, treatment, and management of grazing land resources.

- http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/?cid=stelprdb1043084

Montana Nonpoint Source Management Program

The website below provides links to information on funding for implementing nonpoint source controls, examples of control projects, and Montana's current Nonpoint Source Management Plan. This plan identifies and provides details for BMPs to improve and maintain water quality.

- http://www.deq.mt.gov/wqinfo/nonpoint/nonpointsourceprogram.mcpx

The following would be applied, if warranted, to any BLM authorized activity.

- The total disturbance area would be minimized and to the extent possible.
- Surface disturbances would be co-located in areas of previous or existing disturbance to the extent technically feasible.
- Linear facilities would be located in the same trenches (or immediately parallel to) and when possible, installed during the same period of time.
- Plans of development would be required for major ROWs, renewable energy and minerals development. Such plans would identify measures for reducing impacts.
- Where the federal government owns the surface and the mineral estate is in nonfederal ownership, the BLM would apply appropriate fluid mineral BMPs to surface development.
- Remove facilities and infrastructure when use is completed.
- Vegetation would be removed only when necessary. Mowing would be preferred. If mowed, when possible work would be performed when vegetation is dormant.
- Two-track (primitive) roads would be used when possible.

- Utilization of the Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (i.e., The Gold Book) shall be utilized for the design of roads, utilities, and oil and gas operations.
- Directional drilling, drilling multiple wells from the same pad, co-mingling, recompletion, or the use of existing well pads would be employed to the extent technically feasible to minimize surface impacts from oil and gas development.
- Utilities would be ripped or wheel-trenched whenever practical.
- Remote telemetry would be used to reduce vehicle traffic to the extent technically feasible (e.g., monitoring oil and gas operations).
- Perennial streams would be crossed using bore crossing (directional drill) or other environmentally sound method.
- For activities resulting in major surface-disturbance as determined by the AO, a mitigation monitoring and reporting strategy would be developed and implemented (see the Reclamation Appendix for further guidance).
- Operations would avoid sensitive resources including riparian areas, wetlands, floodplains, waterbodies and areas subject to erosion and soil degradation.
- The BLM would, on a case-by-case basis, use temporary or permanent enclosures (e.g., in woody draw or riparian areas) to promote species diversity, recruitment, and structure.
- Accelerated erosion, soil loss, and impacts to water quality would be reduced by diverting stormwater and trapping sediment during activity.
- Pitless or aboveground closed-loop drilling technology would be used to the extent technically feasible. Recycle drilling mud and completion fluids for use in future drilling activities.
- Where needed, pits would be lined with an impermeable liner. Pits would not be placed in fill material or natural watercourses, and pits may not be cut or trenched.
- Fertilizer would not be applied within 500 feet of wetlands and waterbodies.
- Vehicle and equipment servicing and refueling activities would take place 500 feet from the outer edge of riparian areas, wet areas, and drainages.
- Activity may be restricted during wet or frozen conditions. Mechanized equipment use would be avoided if the equipment causes rutting to a depth of 4 inches or greater.
- Vehicle wash stations would be used prior to entering or leaving disturbance to reduce the transport and establishment of invasive species.
- Invasive species plant parts would not be transported off site without appropriate disposal measures.
- Use alternative energy (solar or wind power) to power new water source developments.
- Overhead power lines, where authorized would follow the recommendations in the most recent guidance from the Avian Power Line Interaction Committee (1994, as amended 2006, 2012).
- Weed management prescriptions would be included in all new treatment projects and incorporated into existing contracts, agreements, task forces, designated weed-free management areas, and land use authorizations that resulted in ground-disturbing activities.
- Whenever possible, ROWs would be constructed within or next to compatible ROW's, such as roads, pipelines, communications sites, and railroads.

- The operator shall be responsible for locating and protecting existing pipelines, power lines, communication lines, and other related infrastructure.
- Potential changes in climate would be considered when proposing restoration seedings when using native plants. Collection from the warmer component of the species current range would be considered when selecting native species.

F.3 Greater Sage-Grouse Required Design Features

This appendix also includes the Required Design Features for Greater Sage-Grouse Habitat. Required Design Features (RDFs) are required for certain activities in all GRSG habitat. RDFs establish the minimum specifications for certain activities to help mitigate adverse impacts. However, the applicability and overall effectiveness of each RDF cannot be fully assessed until the project level when the project location and design are known. Because of site-specific circumstances, some RDFs may not apply to some projects (e.g., a resource is not present on a given site) and/or may require slight variations (e.g., a larger or smaller protective area). All variations in RDFs would require that at least one of the following be demonstrated in the NEPA analysis associated with the project/activity:

- A specific RDF is documented to not be applicable to the site-specific conditions of the project/activity (e.g.due to site limitations or engineering considerations). Economic considerations, such as increased costs, do not necessarily require that an RDF be varied or rendered inapplicable;
- An alternative RDF is determined to provide equal or better protection for GRSG or its habitat;
- A specific RDF will provide no additional protection to GRSG or its habitat.

Required Design Features for how to make a pond that won't produce mosquitoes that transmit West Nile virus (from Doherty [2007])

1. Increase the size of ponds to accommodate a greater volume of water than is discharged. This will result in un-vegetated and muddy shorelines that breeding *Cx. tarsalis* avoid (De Szalay and Resh 2000). This modification may reduce *Cx. tarsalis* habitat but could create larval habitat for *Culicoides sonorensis,* a vector of blue tongue disease, and should be used sparingly (Schmidtmann et al. 2000). Steep shorelines should be used in combination with this technique whenever possible (Knight et al. 2003).
2. Build steep shorelines to reduce shallow water (>60 centimeters [cm]) and aquatic vegetation around the perimeter of impoundments (Knight et al. 2003). Construction of steep shorelines also will create more permanent ponds that are a deterrent to colonizing mosquito species like *Cx. tarsalis* which prefer newly flooded sites with high primary productivity (Knight et al. 2003).
3. Maintain the water level below that of rooted vegetation for a muddy shoreline that is unfavorable habitat for mosquito larvae. Rooted vegetation includes both aquatic and upland vegetative types. Avoid flooding terrestrial vegetation in flat terrain or low lying areas. Aquatic habitats with a vegetated inflow and outflow separated by open water produce 5-10 fold fewer Culex mosquitoes than completely vegetated wetlands (Walton

and Workman 1998). Wetlands with open water also had significantly fewer stage III and IV instars which may be attributed to increased predator abundances in open water habitats (Walton and Workman 1998).

4. Construct dams or impoundments that restrict down slope seepage or overflow by digging ponds in flat areas rather than damming natural draws for effluent water storage, or lining constructed ponds in areas where seepage is anticipated (Knight et al. 2003).
5. Line the channel where discharge water flows into the pond with crushed rock, or use a horizontal pipe to discharge inflow directly into existing open water, thus precluding shallow surface inflow and accumulation of sediment that promotes aquatic vegetation.
6. Line the overflow spillway with crushed rock, and construct the spillway with steep sides to preclude the accumulation of shallow water and vegetation.
7. Fence pond site to restrict access by livestock and other wild ungulates that trample and disturb shorelines, enrich sediments with manure and create hoof print pockets of water that are attractive to breeding mosquitoes.

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F.3.1 Required Design Features for Fluid Mineral Development

Priority Habitat Management Areas (PHMA)

Roads

- Design roads to an appropriate standard no higher than necessary to accommodate their intended purpose.
- Locate roads to avoid important areas and habitats.
- Coordinate road construction and use among right-of-way (ROW) holders.
- Construct road crossing at right angles to ephemeral drainages and stream crossings.
- Establish speed limits on BLM system roads to reduce vehicle/wildlife collisions or design roads to be driven at slower speeds.
- Establish trip restrictions or minimization through use of telemetry and remote well control (e.g., Supervisory Control and Data Acquisition).
- Do not issue ROWs to counties on newly constructed energy development roads, unless for a temporary use consistent with all other terms and conditions included in this document.
- Restrict vehicle traffic to only authorized users on newly constructed routes (use signing, gates, etc.)
- Use dust abatement practices on roads and pads.
- Close and rehabilitate duplicate roads.

Operations

- Cluster disturbances, operations (fracture stimulation, liquids gathering, etc.), and facilities.
- Use directional and horizontal drilling to reduce surface disturbance.
- Place infrastructure in already disturbed locations where the habitat has not been restored.
- Consider using oak (or other material) mats for drilling activities to reduce vegetation disturbance and for roads between closely spaced wells to reduce soil compaction and maintain soil structure to increase likelihood of vegetation reestablishment following drilling.
- Apply a phased development approach with concurrent reclamation.
- Place liquid gathering facilities outside of priority areas. Have no tanks at well locations within priority areas (minimizes perching and nesting opportunities for ravens and raptors and truck traffic). Pipelines must be under or immediately adjacent to the road (Bui et al. 2010).
- Restrict the construction of tall facilities and fences to the minimum number and amount needed.
- Site and/or minimize linear ROWs to reduce disturbance to sagebrush habitats.
- Place new utility developments (power lines, pipelines, etc.) and transportation routes in existing utility or transportation corridors.
- Bury distribution power lines.
- Corridor power, flow, and small pipelines under or immediately adjacent to roads.
- Design or site permanent structures which create movement (e.g. a pump jack) to minimize impacts to sage-grouse.
- Cover (e.g., fine mesh netting or use other effective techniques) all drilling and production pits and tanks regardless of size to reduce sage-grouse mortality.

- Equip tanks and other above ground facilities with structures or devices that discourage nesting of raptors and corvids.
- Control the spread and effects of non-native plant species (e.g. by washing vehicles and equipment).
- Use only closed-loop systems for drilling operations and no reserve pits.
- Restrict pit and impoundment construction to reduce or eliminate threats from West Nile virus (Doherty 2007).
- Remove or re-inject produced water to reduce habitat for mosquitoes that vector West Nile virus. If surface disposal of produced water continues, use the following steps for reservoir design to limit favorable mosquito habitat:
- Overbuild size of ponds for muddy and non-vegetated shorelines.
- Build steep shorelines to decrease vegetation and increase wave actions.
- Avoid flooding terrestrial vegetation in flat terrain or low lying areas.
- Construct dams or impoundments that restrict down slope seepage or overflow.
- Line the channel where discharge water flows into the pond with crushed rock.
- Construct spillway with steep sides and line it with crushed rock.
- Treat waters with larvicides to reduce mosquito production where water occurs on the surface.
- The BLM would work with proponents to limit project-related noise where it would be expected to reduce functionality of habitats that support GRSG populations. The BLM would evaluate the potential for limitation of new noise sources on a case-by-case basis as appropriate.
- As additional research and information emerges, specific new limitations appropriate to the type of projects being considered would be evaluated, and appropriate limitations would be implemented where necessary to minimize potential for noise impacts on GRSG population behavioral cycles.
- As new research is completed, new specific limitations would be coordinated with the NDGF and partners. Noise levels at the perimeter of the lek should not exceed 10 dBA above ambient noise.
- Require noise shields when drilling during the lek, nesting, broodrearing, or wintering season.
- Fit transmission towers with anti-perch devices (Lammers and Collopy 2007).
- Require sage-grouse-safe fences.
- Locate new compressor stations outside PH and design them to reduce noise that may be directed towards PH.
- Clean up refuse.
- Locate man camps outside of PH.

Reclamation

- Include objectives for ensuring habitat restoration to meet sage-grouse habitat needs in reclamation practices/sites (Pyke 2011). Address post reclamation management in reclamation plan such that goals and objectives are to protect and improve sage-grouse habitat needs.
- Maximize the area of interim reclamation on long-term access roads and well pads including reshaping, topsoiling and revegetating cut and fill slopes.
- Restore disturbed areas at final reclamation to the pre-disturbance landforms and desired plant community.

- Irrigate interim reclamation if necessary for establishing seedlings more quickly.
- Utilize mulching techniques to expedite reclamation and to protect soils.

General Sage-Grouse Habitat Management Areas (GHMA)

- Make applicable BMPs mandatory as Conditions of Approval (COA) within GH. BMPs are continuously improving as new science and technology become available and therefore are subject to change. At a minimum include the following BMPs:

Roads

- Design roads to an appropriate standard no higher than necessary to accommodate their intended purpose.
- Do not issue ROWs to counties on mining development roads, unless for a temporary use consistent with all other terms and conditions included in this document.
- Establish speed limits on BLM system roads to reduce vehicle/wildlife collisions or design roads to be driven at slower speeds.
- Coordinate road construction and use among ROW holders.
- Construct road crossing at right angles to ephemeral drainages and stream crossings.
- Use dust abatement practices on roads and pads.
- Close and reclaim duplicate roads, by restoring original landform and establishing desired vegetation.
- *Operations*
- Cluster disturbances associated with operations and facilities as close as possible.
- Use directional and horizontal drilling to reduce surface disturbance.
- Clean up refuse.
- Restrict the construction of tall facilities and fences to the minimum number and amount needed.
- Cover (e.g., fine mesh netting or use other effective techniques) all pits and tanks regardless of size to reduce sage-grouse mortality.
- Equip tanks and other above ground facilities with structures or devices that discourage nesting of raptors and corvids.
- Use remote monitoring techniques for production facilities and develop a plan to reduce the frequency of vehicle use.
- Control the spread and effects of non-native plant species (Gelbard and Belnap 2003, Bergquist et al. 2007).
- Restrict pit and impoundment construction to reduce or eliminate augmenting threats from West Nile virus (Doherty 2007).

Reclamation

- Include restoration objectives to meet sage-grouse habitat needs in reclamation practices/sites. Address post reclamation management in reclamation plan such that goals and objectives are to protect and improve sage-grouse habitat needs.

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F.3.2 Required Design Features for Fire & Fuels

F.3.2.1 Fuels Management

1. Where applicable, design fuels treatment objective to protect existing sagebrush ecosystems, modify fire behavior, restore native plants, and create landscape patters which most benefit sage-grouse habitat.
2. Provide training to fuels treatment personnel on sage-rouse biology, habitat requirements, and identification of areas utilized locally.
3. Use fire prescriptions that minimize undesirable effects on vegetation or soils (e.g., minimize mortality of desirable perennial plant species and reduce risk of hydrophobicity).
4. Ensure proposed sagebrush treatments are planned with interdisciplinary input from BLM and /or state wildlife agency biologist and that treatment acreage is conservative in the context of surrounding sage-grouse seasonal habitats and landscape.
5. Where appropriate, ensure that treatments are configured in a manner (e.g., strips) that promotes use by sage-grouse (See Connelly et al. 2000*)
6. Where applicable, incorporate roads and natural fuel breaks into fuel break design.

7. Power-wash all vehicles and equipment involved in fuels management activities prior to entering the area to minimize the introduction of undesirable and/or invasive plant species.
8. Design vegetation treatment in areas of high frequency to facilitate firefighting safety, reduce the risk of extreme fire behavior; and to reduce the risk and rate of fire spread to key and restoration habitats.
9. Give priority for implementing specific sage-grouse habitat restoration projects in annual grasslands first to sites which are adjacent to or surrounded by sage-grouse key habitats. Annual grasslands are second priority for restoration when the sites not adjacent to key habitat, but within two miles of key habitat. The third priority for annual grasslands habitat restoration projects are sites beyond two miles of key habitat. The intent is to focus restoration outward from existing, intact habitat.
10. As funding and logistics permit, restore annual grasslands to a species composition characterized by perennial grasses, forbs, and shrubs.
11. Emphasize the use of native plant species, recognizing that non-native species may be necessary depending on the availability of native seed and prevailing site conditions.
12. Remove standing and encroaching trees within at least 100 meters of occupied sage-grouse leks and other habitats (e.g., nesting, wintering, and brood rearing) to reduce the availability of perch sites for avian predators, as appropriate, and resources permit.
13. Protect wildland areas from wildfire originating on private lands, infrastructure corridors, and recreational areas.
14. Reduce the risk of vehicle or human-caused wildfires and the spread of invasive species by planting perennial vegetation (e.g., green-strips) paralleling road rights-of-way.
15. Strategically place and maintain pre-treated strips/areas (e.g., mowing, herbicide application, and strictly managed grazed strips) to ail in controlling wildfire should wildfire occur near key habitats or important restoration areas (such as where investments in restoration have already been made).

F.3.2.2 Fire Management

1. Develop state-specific sage-grouse toolboxes containing maps, a list of resource advisors, contact information, local guidance, and other relevant information.
2. Provide localized maps to dispatch offices and extended attack incident commanders for use in prioritizing wildfire suppression resources and designing suppression tactics.
3. Assign a sage-grouse resource advisor to all extended attack fires in or near key sage-grouse habitat areas. Prior to the fire season, provide training to sage-grouse resource advisors on wildfire suppression organization, objectives, tactics, and procedures to develop a cadre of qualified individuals.
4. On critical fire weather days, pre-position additional fire suppression resources to optimize a quick and efficient response in sage-grouse habitat areas.
5. During periods of multiple fires, ensure line officers are involved in setting priorities.
6. To the extent possible, locate wildfire suppression facilities (i.e., base camps, spike camps, drop points, staging areas, heli-bases) in areas where physical disturbance to sage-grouse habitat can be minimized. These include disturbed areas, grasslands, near roads/trails or in other areas where there is existing disturbance or minimal sagebrush cover.

7. Power-wash all firefighting vehicles, to the extent possible, including engines, water tenders, personnel vehicles, and all-terrain vehicles prior to deploying in or near sage-grouse habitat areas to minimize noxious weed spread.
8. Minimize unnecessary cross-country vehicle travel during fire operations in sage-grouse habitat.
9. Minimize burnout operations in key sage-grouse habitat areas by constructing direct fireline whenever safe and practical to do so.
10. Utilize retardant and mechanized equipment to minimize burned acreage during initial attack.
11. As safety allows, conduct mop-up where the black adjoins unburned islands, dog legs, or other habitat features to minimize sagebrush loss.

Literature Cited

Connelly, J.W., M.A Schroeder, A.R. Sands, and C.E. Braun 2000. Guidelines to Manage Sage-grouse Populations and Their Habitats. Wildlife Society Bulletin 28:967-985.

F.3.3 Required Design Features for Solid Minerals

Introduction

The following measures would be applied as RDFs for all solid minerals. They would also apply to locatable minerals consistent with applicable law. The RDFs or BMPs would be applied as appropriate in PH and GH, and to the extent allowable by law (i.e., to prevent unnecessary and undue degradation).

Roads

- Design roads to an appropriate standard no higher than necessary to accommodate their intended purpose.
- Locate roads to avoid important areas and habitats.
- Coordinate road construction and use among ROW holders.
- Construct road crossing at right angles to ephemeral drainages and stream crossings.
- Establish speed limits on BLM system roads to reduce vehicle/wildlife collisions or design roads to be driven at slower speeds.
- Do not issue ROWs to counties on mining development roads, unless for a temporary use consistent with all other terms and conditions included in this document.
- Restrict vehicle traffic to only authorized users on newly constructed routes (e.g., use signing, gates, etc.)
- Use dust abatement practices on roads and pads.
- Close and reclaim duplicate roads, by restoring original landform and establishing desired vegetation.

Operations

- Cluster disturbances associated with operations and facilities as close as possible.
- Place infrastructure in already disturbed locations where the habitat has not been restored.
- Restrict the construction of tall facilities and fences to the minimum number and amount needed.
- Site and/or minimize linear ROWs to reduce disturbance to sagebrush habitats.

- Place new utility developments (power lines, pipelines, etc.) and transportation routes in existing utility or transportation corridors.
- Bury power lines.
- Cover (e.g., fine mesh netting or use other effective techniques) all pits and tanks regardless of size to reduce sage-grouse mortality.
- Equip tanks and other above ground facilities with structures or devices that discourage nesting of raptors and corvids.
- Control the spread and effects of non-native plant species (Gelbard and Belnap 2003, Bergquist et al. 2007).
- Restrict pit and impoundment construction to reduce or eliminate threats from West Nile virus (Doherty 2007).
- Remove or re-inject produced water to reduce habitat for mosquitoes that vector West Nile virus. If surface disposal of produced water continues, use the following steps for reservoir design to limit favorable mosquito habitat:
- Overbuild size of ponds for muddy and non-vegetated shorelines.
- Build steep shorelines to decrease vegetation and increase wave actions.
- Avoid flooding terrestrial vegetation in flat terrain or low lying areas.
- Construct dams or impoundments that restrict down slope seepage or overflow.
- Line the channel where discharge water flows into the pond with crushed rock.
- Construct spillway with steep sides and line it with crushed rock.
- Treat waters with larvicides to reduce mosquito production where water occurs on the surface.
- Require sage-grouse-safe fences around sumps.
- Clean up refuse (Bui et al. 2010).
- Locate man camps outside of PH.

Reclamation

- Include restoration objectives to meet sage-grouse habitat needs in reclamation practices/sites.
- Address post reclamation management in reclamation plan such that goals and objectives are to protect and improve sage-grouse habitat needs.
- Maximize the area of interim reclamation on long-term access roads and well pads including reshaping, topsoiling and revegetating cut and fill slopes.
- Restore disturbed areas at final reclamation to pre-disturbance landform and desired plant community.
- Irrigate interim reclamation as necessary during dry periods.
- Utilize mulching techniques to expedite reclamation.

Literature Cited

Bergquist, E., P. Evangelista, T. J. Stohlgren, and N. Alley. 2007. Invasive species and coal bed methane development in the Powder River Basin, Wyoming. Environmental Monitoring and Assessment 128:381-394.

Bui, T.D., J.M. Marzluff, and B. Bedrosian. 2010. Common raven activity in relation to land use in western Wyoming: implications for greater sage-grouse reproductive success. Condor 112:65-78.

Doherty, M.K. 2007. Mosquito populations in the Powder River Basin, Wyoming: a comparison of natural, agricultural and effluent coal bed natural gas aquatic habitats. Thesis. Montana State University, Bozeman, U.S.A.

Gelbard, J.L., and J. Belnap. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. Conservation Biology 17:420-432.

G. Greater Sage-Grouse: Applying Lek Buffers

G.1 Buffer Distances and Evaluation of Impacts to Leks

The BLM will evaluate impacts to leks from actions requiring NEPA analysis. In addition to any other relevant information determined to be appropriate (e.g., state wildlife agency plans), the BLM will assess and address impacts from the following activities using the lek buffer-distances as identified in the USGS Report *Conservation Buffer Distance Estimates for Greater Sage-Grouse – A Review* (Open File Report 2014-1239). The BLM will apply the lek buffer-distances specified as the lower end of the interpreted range in the report unless justifiable departures are determined to be appropriate (see below). The lower end of the interpreted range of the lek buffer-distances is as follows:

- linear features (roads) within 3.1 miles of leks
- infrastructure related to energy development within 3.1 miles of leks.
- tall structures (e.g., communication or transmission towers, transmission lines) within 2 miles of leks.
- low structures (e.g., fences, rangeland structures) within 1.2 miles of leks.
- surface disturbance (continuing human activities that alter or remove the natural vegetation) within 3.1 miles of leks.
- noise and related disruptive activities including those that do not result in habitat loss (e.g., motorized recreational events) at least 0.25 miles from leks.

Justifiable departures to decrease or increase from these distances, based on local data, best available science, landscape features, and other existing protections (e.g., land use allocations, state regulations) may be appropriate for determining activity impacts. The USGS report recognizes that "because of variation in populations, habitats, development patterns, social context, and other factors, for a particular disturbance type, there is no single distance that is an appropriate buffer for all populations and habitats across the sage-grouse range." The USGS report also states that "various protection measures have been developed and implemented… [which have] the ability (alone or in concert with others) to protect important habitats, sustain populations, and support multiple-use demands for public lands." All variations in lek buffer-distances will require appropriate analysis and disclosure as part of activity authorization.

In determining lek locations, the BLM will use the most recent active or occupied lek data available from the state wildlife agency.

G.2 For Actions in General Habitat Management Area (GHMA)

The BLM will apply the lek buffer-distances identified above as required conservation measures to fully address the impacts to leks as identified in the NEPA analysis.

- Impacts should first be avoided by locating the action outside of the applicable lek buffer-distance(s) identified above. Impacts should first be avoided by locating the action outside of the applicable lek buffer-distance(s) identified above.

- The BLM may approve actions in GHMA that are within the applicable lek buffer distance identified above only if:
    - o Based on best available science, landscape features, and other existing protections, (e.g., land use allocations, state regulations), the BLM determines that a lek buffer-distance other than the applicable distance identified above offers the same or a greater level of protection to Greater Sage-Grouse and its habitat, including conservation of seasonal habitat outside of the analyzed buffer area; or
    - o The BLM determines that impacts to Greater Sage-Grouse and its habitat are minimized such that the project will cause minor or no new disturbance (ex. co-location with existing authorizations); and
    - o Any residual impacts within the lek buffer-distances are addressed through compensatory mitigation measures sufficient to ensure a net conservation gain, as outlined in the Mitigation Strategy

G.3 For Actions in Priority Habitat Management Area (PHMA)

The BLM will apply the lek buffer-distances identified above as required conservation measures to fully address the impacts to leks as identified in the NEPA analysis. Impacts should be avoided by locating the action outside of the applicable lek buffer-distance(s) identified above.

The BLM may approve actions in PHMA that are within the applicable lek buffer distance identified above only if:

- The BLM, with input from the state fish and wildlife agency, determines, based on best available science, landscape features, and other existing protections, that a buffer distance other than the distance identified above offers the same or greater level of protection to Greater Sage-Grouse and its habitat, including conservation of seasonal habitat outside of the analyzed buffer area.

Range improvements which do not impact GRSF, or, range improvements which provide a conservation benefit to GRSG such as fences for protecting important seasonal habitats, meet the lek buffer requirement.

The BLM will explain its justification for determining the approved buffer distances meet these conditions in its project decision.

Appendix AB: Crosswalk between Billings and Pompeys Pillar National Monument RMP/EIS and the COT Report

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INTRODUCTION to SUMMARY of B&PPNM RMP IMPACTS to GREATER SAGE-GROUSE POPULATIONS AS RELATED TO COT THREATS

A number of threats and risks to greater sage-grouse and their habitat have been identified during conservation planning efforts and assessments. Range wide issues were covered in listing decisions made by FWS in 2007 and 2010. This summary table describes impacts to greater sage-grouse from BLM RMP decisions related to the identified threats.

In addition to the actions identified in the RMP alternatives and this table, the Montana/Dakotas Bureau of Land Management (BLM) Greater Sage-Grouse Mitigation Measures and Conservation Actions (Appendix AB), are a compilation of measures employed by the BLM to further mitigate impacts from surface disturbance in priority, restoration, and general sage-grouse habitat, in order to meet the Goals and Objectives set forward in the BLM National Sage-grouse Conservation Strategy and in individual land use plans.

SUMMARY of BIFO RMP IMPACTS to GREATER SAGE-GROUSE POPULATIONS AS RELATED TO COT THREATS

Threats are characterized as: **Y=** threat is present and widespread,
L = threat present but localized**,**
N = threat is not known to be present**,**
U = Unknown.

Management Zone 1, Yellowstone Watershed Population[1]
Threats:
Isolated/ Small Size- N; Urbanization-N; Mining-N; Free-Roaming Equids-N;
Sagebrush Elimination-L; Fire-L; Conifers-L; Recreation-L;
Agriculture Conversion-Y; Weeds/ Annual Grasses-Y; Energy-Y; Infrastructure-Y; Grazing-Y;

Management Zone II, Wyoming Basin Population[1]
Threats:
Isolated/ Small Size- N; Agriculture Conversion-N;
Sagebrush Elimination-L; Fire-L; Conifers-L; Weeds/ Annual Grasses-L; Mining-L; Free-Roaming Equids-L; Urbanization-L
Energy-Y; ; Infrastructure-Y; Grazing-Y; Recreation-Y;

Wildlife Habitat - Management Common to Action Alternatives: Mitigation of surface-disturbing or disrupting activities (including operations and maintenance associate with fluid mineral development) would be applied where needed to minimize impacts of human activities on important seasonal wildlife habitats, consistent with the wildlife stipulations outlined in the Wildlife / Special Status Species and Fluid Minerals sections of Chapter 2. Mitigation measures would be applied during activity level planning if a on-site evaluation of the project area indicates the presence of important wildlife species.

[1-] U.S. Fish and Wildlife Service. 2013. *Greater Sage-grouse (Centrocercus urophasianus) Conservation Objectives: Final Report*. U.S. Fish and Wildlife Service, Denver, CO. February 2013. (Sage Grouse Threat Summary is from the COT Report.)

COT Report Threat – Isolated/Small Populations, Agriculture, and Ex-urban Development[1]				
	Alternative A	**Alternative B**	**Alternative C**	**Alternative D**
Acres delineated as PH	0	191,543 (154,140)[2]	191,543 (154,140)[2]	191,543 (154,140)[2]
Acres delineated as RH	0	63,437(45,555)[2]	63,437(45,555)[2]	63,437(45,555)[2]
Acres delineated as GH	0	116,452(78,575)[2]	116,452(78,575)[2]	116,452(78,575)[2]
Summary of Impacts to GRSG from Isolated/Small populations	Alternative A does not delineate any PH, RH, or GH. However, all action alternatives delineate PH, RH, and GH; constraints placed on other resources/uses are listed below and these vary by alternative. The action alternatives are in agreement with the following conservation measures identified in the COT report specific to PACs: • Retain GRSG habitats within PACs. • If PACs are lost to catastrophic events, implement appropriate restoration efforts. • Restore and rehabilitate degraded GRSG habitats in PACs.			
Land Tenure disposal (acres) Category III[3] (acres available)	7,529 (2,088 acres identified for further study)	50	4,223	170
Land Tenure: Retention Category I (acres)	26,616 acres (no Category I or II)	68,300	108,184	80,060
Land Tenure: Retention Category II (acres)	26,616 acres (no Category I or II)	365,804	321,747	353, 924
Summary of Impacts to GRSG from Agriculture/ Urbanization: Across all action alternatives, the BLM would take advantage of opportunities to consolidate GRSG habitat. All Alternatives technically allow for disposal of lands; however, GRSG habitat would be considered in the analysis. The 170 acres identified for disposal in Alternative D are outside of GRSG habitat. Retention / Acquisition Criteria (Appendix J, J.2.2, J.2.3, pages 6, 7) identify areas for Special Status Wildlife Species (includes sage-grouse).				

[1] Urbanization is listed as" **Not Known to be Present"** in the Yellowstone Watershed population, although it is listed as a , "**Present but localized threat**," in Management Zone II, Wyoming Basin, in the COT Report threats list; however, the alternatives for BIFO contain actions under the realty program that would address this issue (e.g., no disposal of BLM-administered lands within PH). [2] Larger acreage is BLM Administered Federal Mineral Estate, Acreage in parentheses are BLM Administered Surface.
[3] Refer to Appendix J, pages J-3 and 4 for Land tenure Category descriptions.

The action alternatives are in agreement with the following conservation options identified in the COT report specific to ex-urban development:

- Acquire and manage GRSG habitat to maintain intact ecosystems.

While agricultural conversion is considered a wide spread threat to Greater Sage Grouse within the planning area, it is not occurring on BLM administered public lands in Greater Sage Grouse habitat. Future occurrences are unlikely given the land retention criteria presented in Appendix J. Also, due to the larger percentage of private lands in the Yellowstone population area, BLM considers Urbanization a greater threat in the Yellowstone population versus the Wyoming Basin population. The Wyoming Basin has a greater percentage of public lands that would not be available for Urbanization.

COT Report Threat – Energy and Mining				
	Alternative A	**Alternative B**	**Alternative C**	**Alternative D**
Areas closed to fluid mineral leasing –No Lease (acres)	39,730	302,713	65,891	72,915
Areas open to mineral leasing with NSO stipulation (acres)	32,595	28,110	64,135	263,185
Controlled Surface Use (CSU) (acres)	28,337	76,556	102,682	21,436
Timing Limitation (TL)-(acres)	308,116	249,460	316,602	315,317
Acres of long-term (2015-2030) /[1] short-term surface disturbance (includes interim reclamation)- All Ownerships –Total Annual Disturbance	54/108	54/108	54/108	54/108
Acres of long-term /short-term[1] (2010-2014) surface disturbance – All Ownerships – Total Annual Disturbance	37.5/86	37.5/86	37.5/86	37.5/86
Federal Oil and Gas Wells – estimated 2-4 wells per year with short -term disturbance of 13.5-27 acres per year and long-term disturbance of 5.5-15.5 acres per year, when BLM interim reclamation guidelines are followed. [1]				

[1]-Data from "Billings/ Pompeys Pillar Reasonably Foreseeable Development Scenario."

Leased Fluid Minerals

Restrictions on surface disturbance for leased fluid minerals	Lowest level of protection for GRSG in GH and PH	Highest level of protection for GRSG, RH, in PH	Moderate level of protection for GRSG in PH, RH, and GH	High level of protection for GRSG in PH, RH, and GH
Summary of Impacts to GRSG from Oil and Gas Development	Alternatives C, and D, are NSO for PH to leasing and Alternative B closes PH to leasing. Since most of the high development potential has already been leased, and due to the small amount of BLM minerals in the planning area, the surface disturbance acreages do not change among the alternatives (even between the alternatives that have no lease vs. the no-action).			

The action alternatives are in agreement with the following conservation measures identified in the COT report specific to Energy Development:

- Avoid energy development in PACs (Doherty et al. 2010). Identify areas where leasing is not acceptable,
- or not acceptable without stipulations for surface occupancy that maintains GRSG habitats.
- If avoidance is not possible within PACs due to pre-existing valid rights, adjacent development or split estate issues, development should only occur in non-habitat areas, including all appurtenant structures, with an adequate buffer that is sufficient to preclude impacts to GRSG habitat from noise and other human activities.

By limiting disturbances within PH (Alternative B, C and D), RH, and GH (Alternatives B, C, and D), the action alternatives would work towards the objective of reducing threats to intact shrubland. Alternative B would have more restrictions on fluid mineral development than Alternatives C and D, and Alternative A would have the fewest restrictions of all alternatives.

Mining

	Alternative A	**Alternative B**	**Alternative C**	**Alternative D**
Locatable minerals – areas closed and recommended for withdrawal (acres)	39,700	270,977 Recommend a withdrawal from locatable mineral entry in PH	36,955 Recommend a withdrawal from locatable mineral entry in PH and GH	54,761
Mineral materials (acres) (acres closed)	44,583	343,745 PH would be closed to mineral material sales	251,927 PH and GH would be closed to mineral material sales	272,122 PH would be closed to mineral material sales
Coal mining - areas closed to leasing (acres)	26,131	290,048	264,450	280,971 (only allowed if underground)
Summary of Impacts to GRSG from Mining	Alternatives B and D would be more protective to GRSG and GRSG habitat than Alternatives A and C. All of the action alternatives are in agreement with the following COT conservation options: • Avoid new mining activities and/or any associated facilities within occupied habitat, including seasonal habitats.			

COT Report Threat – Infrastructure				
	Alternative A	**Alternative B**	**Alternative C**	**Alternative D**
ROW avoidance areas (acres)	24,203 No ROW avoidance area for sage grouse	185,607 RH and GH would be avoidance areas	355,601 PH would be Avoidance, RH and GH-ROWs would be allowed if suitable sage-grouse habitat can be maintained	349,358 RH and GH-ROWs would be allowed if suitable sage-grouse habitat can be maintained
ROW exclusion areas (acres)	44,014 No ROW exclusion area for sage grouse	211,384 PH would be a ROW exclusion area	39,491 RH and GH-ROWs would be allowed if suitable sage-grouse habitat can be maintained	48,258 RH and GH-ROWs would be allowed if suitable sage-grouse habitat can be maintained
Travel management- routes within 0.6 miles of leks	15% Closed- 7 miles 85% Open- 40 miles Limited = 0%	27%=Open, 13 miles 47%=Closed, 22 miles 25%=Limited, 12 miles	1%=Closed, 0.5miles 93%=Open, 44 miles 6%=Limited, 2.5 miles	6% =Closed- 1 mile 41% =Open, 25 miles 53%=Limited, 22 miles
Travel Management –routes within 4 miles of leks	11% =Closed, 89 miles 84%=Open, 619 miles 1%=Open with restrictions, 13 miles 3%=Limited, 22 miles	42%=Closed, 316 miles 29%=Open 217 miles 28%=Limited, 209 miles	2%=Closed, 4 miles 87% =Open, 690 miles 11%= Limited, 48 miles	8% =Closed, 48miles 41%=Open, 451 miles 51%= Limited, 236 miles
Travel Management Routes in Greater Sage-grouse PH's	92% =Open, 326 miles 8%= Closed, 32 miles	27%=Open,97miles 64%=Closed, 163miles 27%=Limited, 99 miles	91% =Open, 359 miles 9%=Closed, 19 miles	40% =Open, 102 miles 60%= Closed*, 153 miles *-Closed includes Open routes with restrictions including seasonal closures, etc.
Summary of Impacts to GRSG from Infrastructure	Alternatives B, C and D restrict ROWs in PH, which responds to the need (identified in the COT report) to stop population decline and habitat loss by eliminating activities known to negatively impact GRSG and their habitats through reduction in the threat of habitat loss, degradation and fragmentation. The action alternatives are in agreement with the following conservation objectives/options identified in the COT report specific to infrastructure: • Avoid development of infrastructure within PACs (objective). • Avoid construction of these features in GRSG habitat, both within and outside of PACs. • Restrictions limiting use of roads should be enforced.			

- Motorized travel on BLM-administered land (outside of established TMA's) would be limited to existing roads and trails.

Alternative A, in general, has the least protections for GRSG and GRSG habitat from development of infrastructure. All alternatives limit OHV use to existing roads and trails, but Alternative C also contains a 4-mile buffer from leks for route construction. All action alternatives have limitations on route construction and realignments to minimize impacts to GRSG.

COT Report Threat - Fire				
	Alternative A	**Alternative B**	**Alternative C**	**Alternative D**
		Fire and Fuels		
Fire and fuels management	Prescribed burning would be implemented to manipulate vegetation on areas identified for treatment in the range, forestry, and wildlife programs.	Prescribed fire would not be allowed in the Greater Sage-Grouse Habitat ACEC, Greater Sage-Grouse PPAs, or RAs.	Prescribed fire would be allowed in Greater Sage-Grouse PPAs and RAs if the activity would benefit sagebrush communities (ex: achieve a diversity of age class).	Prescribed fire would be allowed in Greater Sage-Grouse PPAs and RAs if the activity would benefit sagebrush communities (ex: achieve a diversity of age class).
		Wildfire		
Fire operations	Fire management is categorized into six (6) Fire Management Units (FMUs). 5 FMUs where negative effects of wildfire and one FMU where wildfire is desired with significant implementation constraints.	Wildfires (natural ignitions) that occur within or adjacent to an area identified for vegetation or fuels treatment would be managed to meet the desired management objectives.	Wildfire management (natural ignitions) for resource benefit not authorized. Heavy equipment use not restricted, unless otherwise restricted (e.g. ACEC's, WSA's, etc.)	Wildfire management (natural ignitions) for resource benefit would be considered for the following areas: (5 ACEC's and 4 WSA's) Heavy equipment would not be used to construct fire lines in crucial winter range, habitat of candidate or special status species, riparian/wetlands or in areas of cultural resource sensitivity or other designated areas (e.g., ACECs, WSAs). Exceptions would be permitted for protection of human life, property and/or to protect resource values from further loss due to unwanted/unplanned natural or human caused wildland fires. Cultural Resource Specialists, Wildlife Biologists, or Resource

		Advisors would be consulted for locations of identified areas before use of or anticipated use of heavy equipment. If heavy equipment is used, rehabilitation work on lines would begin immediately after containment. Heavy equipment could be used in a WSA only if the exceptions in the non-impairment standards are met.
Summary of Impacts to GRSG from Fire Management	The alternatives are in agreement with the following conservation options from the COT report: • Implement the BLM WO IM 2013-128 (Sage-Grouse Conservation in Fire Operations and Fuels Management) until a decision is made on whether or not to incorporate the measure identified in the IM into RMPs. The measures in this IM are referenced in **Appendix ?? BMPs or Design Features** of this document.	

COT Report Threats - Grazing and Range Management Structures

	Alternative A	Alternative B	Alternative C	Alternative D
Total acres permitted for livestock grazing:	387,057	386,092	386,822	387,057
Available AUMs	54,873	54,873	54,873	54,873
Grazing Allotment Categories	Maintain existing allotment management categories (see Appendix S)	Designate those allotments within or containing Sage-Grouse PPAs as management category I. All other allotments would maintain their existing designation and would be updated as resource conditions change	Same as A	Same as B
Allotment Monitoring	Monitor and evaluate the appropriate management actions (grazing systems and range improvements) to ensure range condition and objectives are met on I allotments and maintained on M and C allotment.	Priority Allotments for monitoring and evaluation would be allotments which: Are not meeting standards for rangeland health Contain special status species habitat (including sage-grouse PPAs / RAs) Contain impaired streams non-functional or functioning at risk downward trend riparian areas. Contain invasive plant species.	Same as A	Priority Allotments for monitoring and evaluation would be allotments which: Are not meeting standards for rangeland health. Contain special status species habitat (including sage-grouse PPAs / RAs). Contain impaired streams. Contain non-functional or functioning at risk downward trend riparian areas. Contain invasive plant species. Allotments that have established and implemented management plans during the life of the plan.

Livestock Grazing – Management Common to All Alternatives:

In areas of resource conflicts, installation of structural range improvements would only be considered where grazing practices (change in season of use, reduction of AUMs, increased rest, etc.) are unable to resolve the resource concern. Structural range improvements could be considered where necessary to facilitate the change in grazing management practices. Existing range improvements would be evaluated and modified to address impacts on wildlife populations (e.g. sage-grouse/fence conflicts).

Site specific greater sage-grouse habitat and management objectives would be developed for BLM land within greater sage-grouse priority areas. These objectives would be incorporated into the respective allotment management plans or livestock grazing permits as appropriate.	
Summary of Impacts to GRSG from Grazing	GRSG habitat considerations within livestock grazing allotments would be similar across all action alternatives because the majority of allotments within Priority Habitat are meeting standards (Refer to Table 3.16). Under all alternatives, grazing would be managed to continue to achieve the standards of rangeland health. Include (at a minimum) indicators and measurements of structure/condition/composition of vegetation specific to achieving sage-grouse habitat objectives (Doherty et al. 2011). If local/state seasonal habitat objectives are not available, use sage-grouse habitat recommendations from Connelly et al. 2000b and Hagen et al. 2007. (Appendix AB, pg. AB-7)

COT Report Threats - Sagebrush Elimination, Conifer Invasion, Invasive Species (Vegetation Management)				
	Alternative A	**Alternative B**	**Alternative C**	**Alternative D**
CConversion of Crested Wheatgrass **to**to Native Rangeland (29,727 acres Total)	Crested wheatgrass (160 acres) would be hayed or mechanically treated to increase forage production, improve range conditions, and reduce erosion.	Fifteen percent (4,459 acres) of crested wheatgrass would be converted to native sagebrush/ grassland over the life of the plan. Preferred treatment areas would be areas that are not currently being used in a grazing system to provide early spring grazing and reduce grazing pressure from other areas within a grazing allotment. Priority treatment areas would be in sage-grouse PPAs, RAs and general habitat.	Five percent (1,459 acres) of crested wheatgrass in high density sage grouse population areas would be converted to native sagebrush/grassland over the life of the plan. Preferred treatment areas would be areas that are not currently being used in a grazing system to provide early spring grazing and reduce grazing pressure from other areas within a grazing allotment. Priority treatment areas would be in sage-grouse PPAs, RAs and general habitat.	Eight percent (2,378 acres) of crested wheatgrass acres would be converted to native sagebrush/grassland over the life of the plan. Preferred treatment areas would be areas that are not currently being used in a grazing system to provide early spring grazing and reduce grazing pressure from other areas within a grazing allotment. Priority treatment areas would be in sage-grouse PPAs, RAs and general habitat.
Areas prioritized for vegetation treatments	Manage rangelands to meet health standards consistent with the Standards for Rangeland Health (Standards 1 and 5). No specific habitat restoration or vegetation management actions in the Billings RMP for GRSG	Across all action alternatives, treatments would be prioritized to consider GRSG habitat requirements -Within sage-grouse priority protection areas, only treatments that conserve, enhance, or restore Greater Sage-grouse habitat would be allowed. Treatment methods, including prescribed burning and mechanical treatments would be used to eliminate conifer encroachment and stimulate vegetative re-growth in grassland/shrub land habitats; and to reduce fuels, thin under-stories, recycle nutrients, and create small openings in forested vegetation types. -Identify priority treatment areas for conifer encroachment, including big game winter range, WUIs, current and historic sagebrush habitat, forest meadows and bighorn sheep habitat. -Treatment priorities would be established consistent with State of Montana Noxious Weed guidance.		
Summary of Impacts to GRSG	The action alternatives are in agreement with the following conservation objective/conservation measures from the COT report:			

from Vegetation Management	• Avoid sagebrush removal or manipulation in GRSG breeding or wintering habitats (objective).			
	COT Report Threat - Recreation[2]			
	Alternative A	**Alternative B**	**Alternative C**	**Alternative D**
Issuance of SRPs	-Mitigation of surface-disturbing or disrupting activities (including operations and maintenance associated with fluid mineral development) would be applied where needed to minimize impacts of human activities on important seasonal wildlife habitats, consistent with the wildlife stipulations outlined in the Wildlife / Special Status Species and Fluid Minerals sections of Chapter 2. -SRPs would only be allowed in priority habitat if they are consistent with the goals and objectives for that habitat or species. -Motorized off-road big game retrieval would be authorized by the Field Manager for individuals with a disabled hunter access permit (issued by FWP). *Refer to "Travel Management" in "Infrastructure" section above*.			
Summary of Impacts to GRSG from Recreation	There are no areas open to off-road travel within the planning area in any alternative. All alternatives are in agreement with the following conservation option from the COT report: • Close important GRSG use areas to off-road vehicle use.			

[2] The alternatives for BIFO do contain an action for SRPs. Travel Management is listed under Infrastructure section above.

Appendix AC:
Billings Field Office and Pompeys Pillar National Monument Sign Plan

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BUREAU of LAND MANAGEMENT

BILLINGS FIELD OFFICE and

POMPEYS PILLAR NATIONAL MONUMENT

SIGN PLAN

February, 2013

Submitted By: Tim FINGER — FEB 4, 2013

Billings Field Office Sign Coordinator — Date

Reviewed By: ______________________ — 2/6/13

Pompeys Pillar National Monument Manager — Date

Reviewed By: ______________________ — 2-5-2013

Billings Field Office Assistant Manager — Date

Approved By: ______________________ — 2-7-13

Billings Field Office Manager — Date

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Introduction

The purpose of this Plan is to establish concise and consistent direction and guidance for the sign maintenance program, and outline the responsibilities of the Field Office/Monument staff and State Office Sign Coordinators for the maintenance of signage utilized on all public lands, waters and facilities managed by the Billings Field Office (BiFO).

Effective communication requires the clear, concise delivery of an understandable message through a powerful medium. Signs are one of the avenues for conveying information to the public about the Bureau of Land Management (BLM). They are a key factor in the way the public views the BLM's competency to manage the public lands and waters under its jurisdiction. Signs on the BLM-managed public lands and waters are our "silent employees."

A comprehensive sign program fosters safety, facilitates the management of an area, provides a learning opportunity for visitors, and offers a positive image and identity for all entities involved in the management of that area. On public lands managed by the Billings Field Office, this Plan conforms with and implements the National Sign Guidebook, which established standards and guidelines for signs and the BLM's National Sign Program.

Purpose of Plan

This Plan:

1. Describes the different types of signs and the locations where they are to be used.

2. Outlines the design standards.

3. Provides specific design standards that apply to certain types of signs, including material and specification requirements.

3. Identifies procurement procedures.

4. delineates the inventory and maintenance strategies.

5. Set schedules for implementation

5. Provides reference material and other resources.

Sign Policy/Action

This Plan provides guidance and direction for ensuring that the physical condition of BLM signage is such that it can accurately identify public lands, promote the safety of the public while visiting public lands, provide visitors with information and direction, mitigate user and management issues, and providing for the regular maintenance and professional appearance of BLM signage.

The following principles were used in formulating the Billings Field Office/Pompeys Pillar National Monument Sign Plan and are also consistent with the basis of the Bureau of Land Management National Sign Program:

1. Signs must deliver understandable messages to visitors. Each sign should address a single topic and not include jargon or technical terms. Messages should not be mixed.

2. The established BLM logo must be used, where appropriate.

3. Signs must comply with the Uniform Federal Accessibility Standards (UFAS) and the Americans with Disabilities Act Accessibility Guidelines (ADAAG). Sections 4.1 and 4.30 from both standards provide specific guidance for signs.

4. Signing situations related to vehicular and pedestrian traffic should follow the specifications established in the Manual on Uniform Traffic Control Devices (MUTCD), published by the Federal Highway Administration.

5. BLM-approved international symbols and established signing industry standards must be used for sign design, fabrication, installation, and maintenance.

6. Signs must comply with pertinent Federal, State, and local laws, as appropriate.

7. The standards and guidelines in the BLM National Sign Guidebook (December 2004) must be applied consistently to ensure that areas are safe and to enhance visitors' experiences on the BLM's public lands and waters.

8. Whenever possible, signs should be used in conjunction with other media, such as maps, brochures, interpretive materials, etc. These will use interchangeable layouts, designs, text, maps, and images as much as possible.

Sign Inventory

The first step in an effective sign maintenance program is to have an accurate and current inventory. From this inventory those signs that are damaged, deteriorated, missing or down, can then be identified. A schedule can then be developed to replace these signs making it possible to estimate labor and material costs to install or repair these signs to a good condition. The inventory also provides a baseline for a condition assessment program to ensure that signs are inspected on a regular basis. These assessments will assist in identifying regular maintenance needs so future budgets can be planned and scheduled maintenance can be performed.

The Billings Field Office has a substantial, but incomplete inventory at this time, so a completion of the inventory is a high priority. Billings Field Office has numerous special emphasis areas such as WSAs, ACEC's, SRMA's, OHV areas, Wild Horse Range, etc.. These areas will have a high priority for signing. The Billings Field Office has divided the Field Office into more manageable components for easier work. These areas are described as follows:

Pompeys Pillar National Monument: This land parcel includes the 51 acre National Monument and its related infrastructure and the adjacent ACEC for a total of 432 acres.

Big Horn County, Montana: All public lands located within Big Horn County, which includes only small isolated parcels of public lands. However BLM does work closely offsite with other agencies located in this area, such as the Crow Indian Reservation, the Northern Cheyenne Indian Reservation, and the Little Big Horn Battlefield National Monument. Administrative Sites: This includes the Britton Springs facility, the Bridger Fire Station, Field Office, Interagency Fire Center at Billings Airport, Sundance Lodge facility, etc..

Carbon County: This land mass includes the Pryor Mountains region, the Beartooth front region, and the large blocks of public lands between them, which overall includes several Travel Management Areas, ACECs, the Pryor Mountain Wild Horse Range, and several WSAs.

Golden Valley County: This area includes public lands on a portion of the Snowy Mountains and small blocks of public land elsewhere. It has a segment of the Nez Perce National Historic Trail on it as well, located on private lands.

Musselshell County: This area has blocks of public lands of varying size interspersed with private lands.

Stillwater County: Small block of public lands, some receiving public use, other isolated and inaccessible.

Wheatland County: Small and isolated tracts of public lands.

Yellowstone County: This area has a limited public land base, but has intensive use at popular Recreation Areas with a large urban interface.

Big Horn County, Wyoming: The Billings Field Office manages/administers 4,300 acres of public land in Big Horn County, Wyoming, which includes the southernmost part of the Pryor Mountain Wild Horse Range. The BLM works closely with the National Park Service as a portion of the Pryor Mountain Wild Horse Range (PMWHR) is located on the Big Horn Canyon National Recreation Area. The Pryor Mountains and Big Horn Tack-On WSAs both extend into Wyoming.

The BiFO staff will use Form 9130-4, "Sign Inventory/Maintenance Form", to ensure a consistent inventory of all signs. Staff will enter information from this form into the Facility Inventory Maintenance Management System database since funding to maintain signs are obtained through this system. The inventory may also be entered into a GIS system either from a hard copy or through data collection with a GPS unit. Digital photographs may be taken and attached to the inventory sheets or entered directly into the GIS database. Staff will include all of the following items on an inventory form or in a GIS database for each sign:

a. Date inventoried and name of person conducting the inventory;

b. Location (initially identified on a map or as mileage from a starting point);

c. All language on the sign;

d. Size, color, and shape of sign (height, length, etc.);

e. Size,

f. Sign material;

g. Condition of sign (good, deteriorated, damaged, missing/down, or obsolete);

h. Type of post and attachment system (4X4 treated lumber, metal fence post, etc.);

i. Condition of post (good, deteriorated, damaged, missing/down, obsolete); and

j. Notes (poor location, accessibility issues, vegetation or terrain features blocking view of sign, or anything else that must be addressed later in the planning process).

When the inventory is complete, BiFO Staff will place all sign locations on a map of the area, with the detailed information cross-referenced to the Facilities Inventory Maintenance Management System. The map may consist of the several "bite-size" area maps used during the inventory (such as for the Pompeys Pillar NM/ACEC). Eventually, BiFO intends to combine all inventory data on one large map to facilitate the coordination of signs across the entire Field Office.

A working file will be established and maintained by the Field Office Sign Coordinator. Included in this file will be the inventory data, schedule of implementation, Review results, a copy of this plan, Inventory Form, sign examples and designs, encroachment permits, and any relevant communication and directives.

Sign Review

Each sign should be reviewed every 5 years to answer the following questions and determine compliance with the Sign Plan:

a. Is the sign consistent with existing planning documentation (resource management, activity, or project plans, etc.)?

b. Is this sign needed? Does it serve a purpose? Is it one of several in an area? Have things changed in this location so that the sign is no longer necessary?

c. Is the sign effective? Is the message inappropriate or confusing? Is lettering too small to be read from a high-speed vehicle?

d. Is the location of the sign still appropriate?

e. Are sign and post materials appropriate for year-round conditions, protection from vandalism, etc.?

f. Does the sign complement the rest of the signs in the area?

g. What is the condition of the sign? Even if the message is appropriate and the location is a good one, is the sign faded? Is it time to replace it?

h. Is each sign meeting required rules and regulations, such as MUTCD, UFAS/ADAAG, etc.?

Sign maintenance will be planned and scheduled annually during preparation of the annual work plan so it can be performed on a regular basis. Sign condition assessments should be performed on signs at the minimum of once every 5 years. See tentative Schedule below for details.

Billings Field Office/Pompeys Pillar NM Sign Plan Schedule				
Area (by priority)	Initial Inventory Dates	Review Dates		Notes
Pompeys Pillar NM	2013	2018	2023	Follow-up local project plan under development by staff
Administrative Sites	No record	2013		
Yellowstone County	2008 - 2009	2014	2019	High Priority for inclusion in Activity-level Plans (TMA, SRMA, etc.)
Carbon County	2008-2010	2014	2019	High Priority for inclusion in Activity-level Plans (TMA, SRMA, etc.)
Musselshell County	2008	2013	2018	Medium Priority for Activity-level Plans (TMA, ACEC)
Golden Valley County	2008	2013		Low priority. No or limited public access to public lands
Stillwater County	2013	2018		Low Priority - No or limited public access to public lands
Wheatland County	Not done			Low Priority- No signs – no public

				access
Big Horn County, MT	Not done			Low Priority - No signs – no surface public lands
Big Horn County, WY	2008 -2010	2014	2019	Small amount of data – included with Carbon County

It intended that condition assessments be performed in conjunction with other assessments such as recreation sites, administrative sites, roads and trails, in an effort to increase efficiency and reduce the resources needed to perform similar actions within the same area.

Condition assessments will be performed to determine the condition and effectiveness of BLM signage. This includes evaluating the legibility, appearance, visibility, reflectivity, verification of location, condition of the sign support structure, and condition of the sign itself using the following condition ratings: Good, Deteriorated, Damaged, Missing/Down, Obsolete. The following information, at a minimum, should be collected while performing a sign condition assessment. The sign ID number (the unique identification number assigned within the sign data base for each sign), inspectors name and the date of inspection, the condition rating of the sign, and the condition rating of the sign support structure, and a current digital photo of the sign.

The following definitions of the Condition Ratings should assist in determining the condition of a sign.

Good – The sign may have experienced some weathering, but its lettering and symbols are legible. The sign is intact, with no holes or broken portions. It may need some cleaning to eliminate accumulated dirt and some minor touch up painting. No vegetation or other objects obscure the sign.

Deteriorated – The sign has been extensively impacted by weathering, requiring extensive cleaning and painting to restore it to its original condition. Lettering and symbols are just legible, and reflectivity is about half of what it was when the sign was installed new. Vegetation may also be starting to encroach on the sign. There may also be minor damage to the sign. These signs should be scheduled to be repaired or replaced; vegetation should also be cleared to restore visibility. Signs that are not able to be restored or repaired should be scheduled to be replaced.

Damaged – The sign is weathered to the point that its message is no longer legible. It has severe damage from holes or other vandalism. The sign may be repaired temporarily, but it should be replaced as soon as possible.

Missing/Down – The sign is either missing or damaged beyond repair. If a sign is still needed, a replacement sign should be ordered immediately.

Obsolete – The sign message is outdated or incorrect. Sign should be updated or removed as soon as possible.

If any action is taken on a sign, that action should be noted and the information added to that specific sign's record within the sign data base. This is to ensure the information contained within the data base is kept current. Actions include:

1.) Install, which is the initial placement and positioning of a sign.

2.) Inspect which is to view or examine officially, checking for structural integrity and whether the sign message is legible.

3.) Replace, which is the exchange of a sign with one that is identical to the sign that was originally placed.

4.) Repair, is the fixing or restoring of a sign to a good or sound condition, from a damaged or deteriorated condition.

Sign Categories

Following the BLM Nationwide standards, BiFO signs are grouped into the following categories: identification signs; guide signs; informational signs; traffic control devices; regulatory, warning, and safety signs; and a miscellaneous group that includes temporary, specialty and special event signs. Each of these categories has its own requirements and functions. Messages should not be mixed on a single sign or in a grouping of signs if it leads to sign clutter.

A. Identification Signs. Identification signs help to orient the visitor, project the presence and image of the BLM to the visitor, and identify important areas, facilities, and visitor amenities. These signs also provide public land visitors with a ready recognition of BLM facilities, projects, and services. Messages are primarily text and should be limited to key ideas and information. These signs should not contain any interpretation. If an area is cooperatively managed, an identification sign may display the names/logos of the other entities.

   Identification signs must be the standard truncated shape, be recreation brown in color, and include the BLM emblem of proportional size.

B. Administrative Signs. These signs are used to identify office buildings, field stations, such as Britton Springs visitor centers such as at Pompeys Pillar NM, etc., and must include a raised emblem.

   All Administration signs must be the standard truncated shape, be recreation brown in color, and include the BLM emblem of proportional size.

C. Feature Signs (Kiosks). The BiFO has a standard design and layout for Kiosks, which includes a map on the left side, resource information and regulations on the right, and contact numbers on the bottom. There is a brown banner along the top with the name of the site in the middle and a BLM logo and American Flag on either side. Kiosks are located only at high use areas, specifically at parking lots, trailheads, staging areas or entrance portals where vehicle pull-outs are available.

   The Pompeys Pillar National Monument has its own but similar design and layout for its Kiosks.

D. Area Signs. These signs designate the primary entrances to a popular land area, facility, or group of facilities. Area signs are located along primary access routes serving each area. This includes Pompey Pillar National Monuments, the South Hills Off-highway Vehicle (OHV) area, and the other BiFO Special Recreation Areas. The emblem may be raised on this type of sign, depending on the significance of the area.

   These signs are recreation brown in color, and include the BLM emblem of proportional size.

E. Guide Signs. Guide signs direct the visitor to a specific destination, such as facilities, projects, features, or points of interest. These signs will typically use arrows and distance indicators. These signs must be truncated in shape, be recreation brown, and contain the BLM emblem, unless a different shape is dictated by another jurisdictional agency such as a State highway department for a highway right-of-way. International symbols may be used when possible to provide supplemental information in a simple, concise manner. Directional signs will be located to provide the visitor adequate time to make a decision. Reassurance markers (route markers) may be placed along roads and trails, typically at the beginning, at the end, at intersections, or periodically along the route. The type of sign will vary depending on the project, such as large square Nez Perce NHT signs to brown fiberglass route markers along BLM designated roads and trails. As a general standard, the BiFO will use brown for direction, red or yellow for warning, and white for informational along travel routes.

F. Informational/Interpretive/Regulatory Signs/Panels. Informational signs which provide limited educational opportunities and identify unique and unusual features as well as appropriate regulations. They enhance the public's awareness and appreciation of the public lands and waters. The BFO will use this type of sign at entrance portals and high destination area such as the Four Dances Natural Area/ACEC and Sundance Recreation Areas, Pompey Pillar NM, etc.

   Specifically, the information should be based on a solid theme and central message.

Graphics, poetry, or other art forms may be used to illustrate the theme. Stories or descriptions of events unfolding should be used to teach concepts instead of identifying straight facts. Titles should use five words or less to identify the point or idea. Subtitles should be used to identify the theme and introduce text paragraphs. Appropriate colors reflecting the surrounding environment should be incorporated into the design. Letters should be at least 24 points in size. Entire text blocks should not be in all capital letters. Text should be written to convey a simple message. Graphics should be clear, easy to identify, and complement the text.

Regulatory signs should be legible and plainly displayed from any approach to a facility or feature, whether the visitor is on foot or in a vehicle. When appropriate, signs should be erected to assist in controlling authorized use, in deterring unauthorized entry and use, or in precluding accidental entry. The size, color, lettering, and the interval of posting must be appropriate for each situation.

The message on Regulatory Signs should be positive rather than prohibitive or negative, and should explain the reason for the restrictions to enhance the visitor's understanding. Signs should be rectangular, unless otherwise directed by a higher authority (MUTCD), and do not have to display the BLM emblem.

G. Accessibility. These signs identify particular areas or facilities/programs that are universally accessible. There are four areas or facilities where the International Symbol of Accessibility (ISA) is required to be posted according to the two Federal Accessibility Standards (the Uniform Federal Accessibility Standards (UFAS) and the Americans with Disabilities Act Accessibility Guidelines (ADAAG)). The four areas/facilities requiring the ISA (ADAAG Section 4.1.2.(7) are accessible parking spaces, accessible restrooms, accessible loading zone, and any accessible entrance to a building. The BiFO will mark and maintain these as the highest priority field office wide.

H. Miscellaneous Signs. Temporary signs may be necessary at construction sites, fires, etc., and will be used only for specific periods of time. They are temporary, highlight special conditions or hazards, and may include seasonal messages or special precautions. They will be placed at appropriate high-visibility areas and removed when no longer necessary. Signs should be mounted appropriately and not fastened to trees or other natural features.

Signs used under emergency responses have no specific guidelines and will be designed and constructed as needed by the BiFO staff, with as much input and assistance form other affected parties as practical, given the circumstances.

The temporary use of banners and signs designating a special, one-time public event on the BLM public lands and waters is allowed. Although there are no specific guidelines, the National Sign Center may be contacted to design and create banners for special events, such as National Public Lands Day, National Trails Day, National Fishing and Boating Week, Great Outdoors Week, the Clark Days Commemoration, etc.

I. General Purpose Signs. These are signs that are not specific to the BLM. Stop signs, speed limit and other traffic signs and Occupational Safety and Health (OSHA) signs are examples of signs that fall into this category.

OSHA signs must conform to the Occupational Safety and Health Standards (29 CFR 1910.145). BLM Staff are required to acquire them from Prison Industries or locally if not available and if permitted by the State Sign Coordinator.

Traffic signs have very stringent requirements and must be designed and installed in accordance with the Manual on Uniform Traffic Control Devices (MUTCD). These signs include any type of vehicular-related traffic control messages. Traffic control devices must be justified by legal warrants signed by a professionally registered engineer as specified in MUTCD.

Design Standards

All Sign Standards set in the BLM Sign Manual (BLM MS-9130) will be followed. All sign standards set by the U.S. Department of Transportation will be followed, when applicable. If other agency standards apply, such as sign standards specific for the Nez Perce National Historic Trail, these will be adhered to, with a copy of the sign standards retained in the Sign Plan file for future reference.

Relationship to other Plans

The Resource Management Plan (RMP) discusses in general terms the BiFO management strategy and direction. In its new draft RMP (2013), the BiFO travel management decisions are to designate a motorized and non-motorized route system. All non-designated but existing routes would be closed, possibly rehabbed, but not signed. Only designated routes would be signed as open. Specifics of implementation, including signing, brochures, and maps will be addressed in Activity-level Travel Management Plans. Special Recreation Management Areas (SRMAs) would also be addressed through Activity-level plans. ACECs may or may not have Activity-Level Plans.

Permits, Clearances, and Inventories

Appropriate clearances such as Endangered Species Act (ESA), inventories for cultural resources, or National Environmental Policy Act (NEPA) documentation may be required. Prior to the BLM installing any sign, the appropriate jurisdictional agency must grant its permission. This may include the State Department of Transportation if the sign will be placed along a State highway, or the county road and bridge department if the sign will be installed along a county road. Encroachment Permits issued by the managing agency will be retained in the BiFO Sign Plan File.

When placing BLM signs on roads under other jurisdiction, BiFO staff should coordinate signing requirements with that agency. In those instances, staff should follow the placement and installation guidelines and standards of the agency with jurisdiction of the road.

Sign Placement

Placement involves the horizontal positioning, vertical height, and location along the roadway where the sign is placed. The general standard for BiFO is to place all signs on the right-hand side of the traveled way as close to the standard location as is practical.

Consider the following guidelines when selecting sign placement locations:

1. Place signs where they provide adequate time for proper viewer response, considering factors such as speed, trail or road conditions, intermediate intersections, and road/trail geometry.

2. Select locations that minimize viewing obstructions. Some common placement locations to be avoided include:

- Dips in the roadway or trail.
- Just beyond the crest of a hill.
- Where a sign could be obscured by other signs.
- Where the sign may interfere with the normal operation of the facility.
- Where there is increased need for drivers to focus on the roadway.
- Too close to trees or other foliage that could grow to cover the sign face.
- Snow removal areas.
- Site location where a significant viewpoint is impaired

3. Erect signs individually on separate posts or mountings except where one sign supplements another, such as a warning sign with an advisory speed plaque, or where route markers and destination signs must be grouped.

All signs need to be visible to users in time for them to see the sign, perceive the message, react, and complete the necessary maneuver considering approach speeds and conditions.

Place regulatory signs at or near where their mandate or prohibition applies or begins.

Warning signs are normally placed in advance of the situation to which they call attention to allow adequate time for proper response.

Sign faces should be placed at approximately right angles to and directly facing traffic they are intended to serve. On curves, orient the sign to face the oncoming traffic—not the road edge.

Sign Priority

Priorities for signing are listed below in order of importance:

1. Public health and safety.

2. Entrances to and boundaries of areas of national significance (e.g., Pompeys Pillar National Monument, Nez Perce and Lewis and Clark National Historic Trails, Wilderness Study Areas) – NLCS units and the PMWHR.

3. Special management areas (e.g., recreation sites, watchable wildlife sites, trails, back country byways, etc.).

4. Visitor enhancement and convenience.

5. Major concentrations of BLM-managed public lands and waters on major thoroughfares crossing large blocks of public lands.6. Isolated or small parcels of public lands with no or limited access or use.

7. Conformance of existing signs to new standards, especially in high Priority Areas (see above)

Sign Ordering and Storage

All signs will be ordered through appropriate administrative procedures described in other sections of this plan. The signs may be stored at sites throughout the FO prior to installation but individual programs are responsible for them. Any obsolete, damaged, or decayed signs which can be recycled should be brought to a central location designated by the Field Office Manager and disposed of from there on an annual basis, if necessary. Individual programs will be responsible for their own signs and funding. If several programs are involved, the programs will split the cost.

Sign Data Base

The sign data base is intended to be on an electronic shared drive readily accessible to all BiFO staff members and as a paper file located in the Field Office. Any changes on the ground should be changed at the same time on this database and meet the standards as noted above (See "Sign Inventory" section). A new Form 9130-4, "Sign Inventory/Maintenance Form" will be filled out for each new or replacement sign, kiosk, or interpretive panel. At least once each fiscal year the Field Office Sign Coordinator shall imitate a field office-wide staff review of deteriorated, damaged or newly required signs.

Staff Responsibilities

The following key positions are described, to better define duties and responsibilities, regarding sign maintenance.

National Sign Center: Establishes quality control, consistency, and standardization in all BLM signage. Identifies and recommends other public and private sources for the design and production of BLM signs. The Sign Center ensures that all materials produced are consistent with current laws, regulations, and policies. The Sign Center should produce all BLM signs and sign orders in a timely and cost-effective manner. The Sign Center provides expertise on design and materials when requested.

The National Sign Center in Rawlins, Wyoming, is the clearinghouse for all custom BLM signs. Safety and traffic signs should be ordered from the Federal Prison Industries (Unicor). The Sign Center will determine the most efficient cost-effective source whether it be in-house or contracting for the design and production of these signs. The Sign Center is available for assistance with special interpretative products.

National Sign Coordinator: Develops and maintains the BLM National Sign Program. Creates and develops program objectives. Develops current standards and evaluate procedures. The National Sign Coordinator provides program standards and specifications. The National Sign Coordinator approves the appropriate content on all BLM standard signs and has review and approval authority for all BLM signs not conforming to the established standards in the Sign Guidebook; Coordinates the numbering, printing, and issuing of all standard BLM signs. Coordinates and collaborates with all State Sign Coordinators in developing a National Sign Strategy and a National 5-Year Sign Maintenance Plan; Coordinates with all State Offices, program offices, State representatives, and Field Offices to achieve management goals. Has review and approval for all requests for alternative sources of design and production for all BLM signs. Coordinates and collaborates with the National Interpretive Lead on the design and production of interpretive waysides. Coordinates and collaborates with the National Accessibility Lead to ensure the design and production of all signs meet accessibility guidelines.

State Sign Coordinator: The State Sign Coordinator is responsible for producing and updating the State's 5-year sign plan and providing the data to the National Sign Coordinator. The State Sign Coordinator also provides guidance regarding sign maintenance issues and tracks overall sign maintenance needs identified within the statewide sign database. The State sign coordinator will be available to assist and provide guidance to Field Office staff.

Field Office Sign Coordinator: The Field Office Sign Coordinator is responsible for ensuring that the sign database inventory is complete and up to date. They are also responsible for creating and maintaining the Field Office's 5-Year Sign Plan and ensuring that maintenance, and replacement schedules for signs are performed on a regular basis and in an efficient manner. They coordinate with the Field Office personnel that can help and assist with sign maintenance such as equipment operators, recreation planners, and engineers. These are the "on the ground personnel that keep the signage in good condition and looking professional.

Staff Input

Prepared by (team members):

Tim Finger – Outdoor Recreation Planner
Nancy Bjelland – Wild Horse and Burro Program Specialist, Safety
Jared Bybee- State Lead Wild Horse and Burro and Rangeland Management Specialist
Sheila Cain – GIS Specialist
Tom Carroll – Realty Specialist
Dustin Crowe – Rangeland Management Specialist
Don Galvin – Park Ranger
Paul Green – Equipment Operator
Jeff Herriford – Law Enforcement Officer
Irv Leach – Fire Management Officer
Ernie McKenzie – Wildlife Biologist/Fisheries and Riparian Specialist
Larry Padden – Natural Resources Specialist (Weeds)
Jay Parks – Wildlife Biologist
Carolyn Sherve-Bybee – Archeologist, RMP Planning Lead
Carmen Thomason – Fire Education and Mitigation Specialist
Kachmir Watt – Range Specialist
Jared Werning – Equipment Operator

References

Highway Safety Act of 1966 (as amended).

Omnibus Public Land Management Act of 2009 (public Law 111-11)

National Environmental Policy Act of 1969 (NEPA), as amended. 42 U.S.C, 4321 et seq.

The Archaeological Resources Protection Act of 1979 (P.L. 96-95; 93 Stat. 721; 16 U.S.C. 470aa)

The National Trails System Act of 1968, as amended, P.L. 90-543, P.L. 110-229 and 16 U.S.C. 1241-1251

The Sikes Act, as amended, 16 U.S.C. 670a-670o and P.L. 90-465

The Architectural Barriers Act of 1968, as amended, 42 U.S.C. 4151

Executive Order 13195 (Trails for America in the 21st Century)

Executive Orders 11644 (1972) and 11989 (1977) – Off Road Vehicle Management Policies

BLM Travel and Transportation Manual (MS-1626)

42 U.S.C. 4332 – Cooperation of Agencies

BLM Manual 1601 – Land Use Planning

BLM Manual 9100 – Facilities Planning, Design, Construction, and Maintenance.

BLM Manual 9130 – Sign Manual

43 CFR 2920 – Leases, Permits, and Easements

43 CFR 8342 – Off-Road Vehicles: Designation Procedures

43 CFR 8364 – Visitor Services: Closure and Restriction Orders

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43 CFR 8341.2 or 8364.1. Temporary Closure or Restrictions.

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